MUREX
TEAM5-2018

Children's Hospital and Medical Center

Omaha, Nebraska

TEAM5-2018

Submittal Report
AEI Student Design Competition 2018

MUREX
TEAM5-2018

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Each symbol will represent the disciplines next to it. These symbols will be used to show integration between the disciplines during the design process. Contents of the Table are hyperlink to the section for better navigation.

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1.1.0 Executive Summary

This submittal outlines how Murex successfully came together to deliver a high performance design for the proposed design challenges. These challenges include designing a high performance enclosure, smart building integration and disaster response planning. Murex met these challenges with the following design highlights:

DESIGN CHALLENGE	MUREX SOLUTION
High Performance Enclosure	- Rear-Ventilated Terracotta Facade
Smart Building Integration	- Geothermal Piles running through Drilled Pier Foundation - Integral Building Monitoring System - Voided Slab Floor System
Disaster Response Planning	- FEMA Tornado EF5 shelter - Air quality is not sacrificed during emergency

The Children's Hospital and Medical Center addition located in Omaha, Nebraska will be referred to as CHMC from this point forward.

1.1.1 Introduction

Structural, Mechanical, Lighting/Electrical, and Construction come together to create a multi-disciplinary design team guided by the core values of safety, integrity and sustainability. Together, team members consider the role and concerns of the architect.

A common theme of success is connected to each individual who make up this team; we are all a shade of achievement. We are a team rich in knowledge and believes in the power of collective minds working together toward one all encompassing design. It was decided that our emblem would be inspired by a fragment from an 11th-century Byzantine robe showing griffins embroidered on a delicate tyrian purple silk, woven from murex dyed threads. Tyrian purple is the color of royalty and griffins the sign of power. Murex is the original source of the traditional royal purple and to us is the source of the rich knowledge. The griffins are a sign of power. Together, they become our team identity. From this point forward, we will be known as Murex, a team rich in knowledge and powerful in application.

For the 2018 AEI Student Design Competition, Murex is devoted to designing a high performance addition for the CHMC that caters to the growing Omaha community.

Murex determined the following as the project's key design elements that personify integration and collaboration: the facade, the geothermal drilled piers, the voided slab system, and the building control system. Murex has focused its design on maximizing safety, integrity, and sustainability to create a cohesive, efficient design within each of these key areas.

Facade

A working enclosure design that elevated the patient experience and benefitting the sustainability of the entire project.

Energy Piles

Collaboration across 3 disciplines allowed for implementation of spiral ground source loop within the drilled piers foundation to be used as a geothermal energy system

Voided Slab

A voided slab floor system design is able to be successfully implemented due to the open communication between all disciplines.

Smart Building System

Systems throughout the entire building are connected through a building monitoring system, increasing the occupant experience and optimization of all the building systems.

1. Integration narrative

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1.2.0 Team Introduction

The Murex team is made up of ten individuals, who volunteered their time for the past 9 months creating the best design and construction schedule for this project. Since this was done on a volunteer basis, the team makeup was mostly decided by the willingness to participate. The breakdown of Murex disciplines are:

Discipline	Number of Students
Architecture/Graphic Design	1
Structural	3
Mechanical	2
Electrical	1
Construction	3

Playing to each individual's strengths allowed Murex to excel in its decision making and goal setting. The team member of Murex filled out a Strength Quests Strengths Map to understand the large scale strengths of each of our members to understand the best way to communicate and interact with one another. The strengths maps can be seen on (Pg 14)

Most of the members of Murex are undergraduate students with this being the first hospital they have designed. To understand the level of skill that everyone was bringing to the team, Murex created a Personal Skill Ranking Table for each discipline. These tables helped Murex determine what areas would need the most additional guidance and where the most learning would occur, as well as where the team was going to excel and could implement more challenging design protocols. These tables can be seen below:

1	2	3	4	5
Little/No Knowledge		Average		Very Experienced

PERSONAL SKILLS RANKING STRUCTURAL

SKILL	STRUCTURAL MEMBER 1	STRUCTURAL MEMBER 2	STRUCTURAL MEMBER 3
LOAD DETERMINATION	4	5	4
OVERALL CONCRETE DESIGN	3	4	3
FOUNDATION DESIGN	1	1	1
GRAVITY SYSTEM DESIGN	3	4	2
LATERAL SYSTEM DESIGN	2	1	3
COMPUTER MODELING	3	5	4
DRAFTING	2	3	3

PERSONAL SKILLS RANKING ELECTRICAL

SKILL	ELECTRICAL MEMBER 1
POWER DISTRIBUTION	4
SMART BUILDING SYSTEMS	2
LIGHTING DESIGN	3
LIGHTING CONTROLS	3
FIRE ALARM SYSTEM INFRASTRUCTURE	1
DATA/SECURITY INFRASTRUCTURE	1
ALTERNATIVE ENERGY GENERATION	1

PERSONAL SKILLS RANKING MECHANICAL		
SKILL	MECHANICAL MEMBER 1	MECHANICAL MEMBER 2
LOADS	5	3
SYSTEM SELECTION	3	2
ENERGY MODELING	2	1
PRESSURIZATION	4	2
CONTROLS & BUILDING MONITORING SYSTEM	2	1
ACOUSTICS	2	3
COST ANALYSIS	1	1
PLUMBING	2	3
MED-GAS	1	1
FIRE PROTECTION	2	3

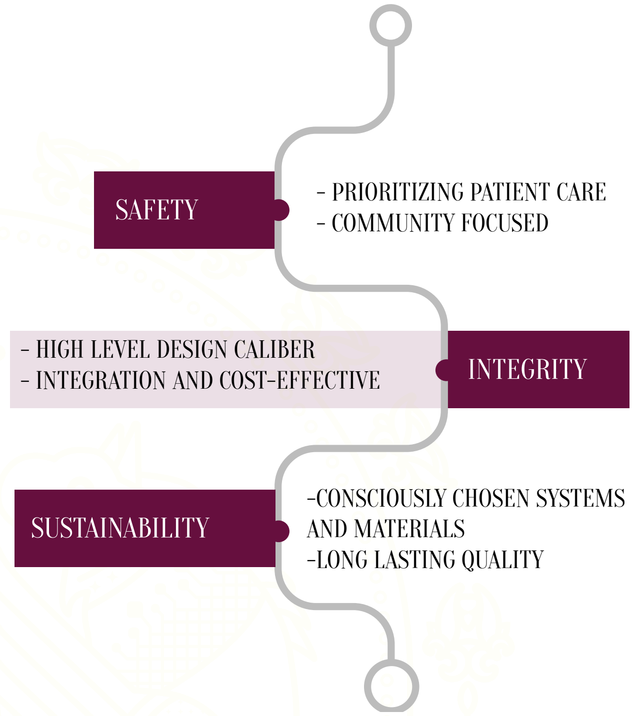
PERSON SKILLS RANKING CONSTRUCTION			
SKILL	CONSTRUCTION MEMBER 1	CONSTRUCTION MEMBER 2	CONSTRUCTION MEMBER 3
SCHEDULING	4	4	3
QUANTITY TAKEOFF	3	5	2
COST ESTIMATING	2	4	4
VALUE ENGINEERING	2	3	2

1.3.0 Project Introduction

The facility is a new construction building on the existing campus. It provides additions to the NICU and PICU units and a new Cardiac Care Center, and a Fetal Care Program. This new six story tower and four story ancillary base project site is located adjacent to West Dodge Road, one of the busiest roads in the city. Throughout the project design, Murex wanted to deliver solutions to the overall project challenges set, as well as align with individual team goals. With this in mind, Murex has focused its design on maximizing safety, integrity, and sustainability to create a cohesive, efficient design.

1.3.1 Project Goals

The primary goals of the Murex are to maximize safety, integrity, and sustainability. The three of these concepts are used to create a cohesive, efficient design.



These goals were selected for the following reasons:

Safety

To emphasize the role of the facility in the community and focus on patients, the design incorporates the services for tornado refuge and shelter, maximizes infection control in the equipment chosen, and create environments where medical services can be provided as required.

Integrity

The team designed at a high caliber level while maintaining cost efficacy. The integration of all systems was paramount to supply quality work to meet and surpass the needs of the patients.

Sustainability

Our design focuses on using resources wisely and providing long-lasting quality. The decisions made on the project were energy efficient to meet needs, rather than elevate overall cost for unnecessary items when the money could be allocated to meet patient needs.

Attaining these goals required tight-knit coordination, creative problem solving and team unity.

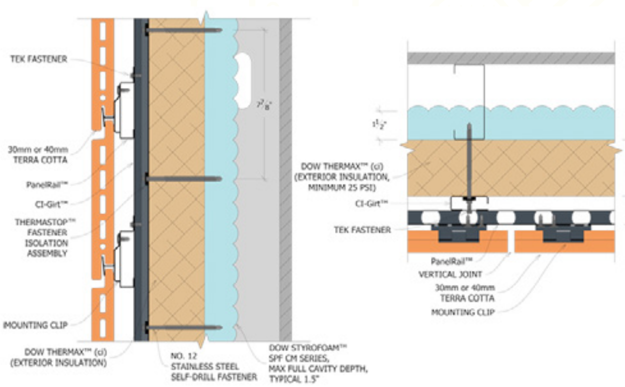
1.3.2 Design Challenges

Three main design challenges were presented for this project: high-performance enclosure, smart building integration, and disaster response planning.

Enclosure

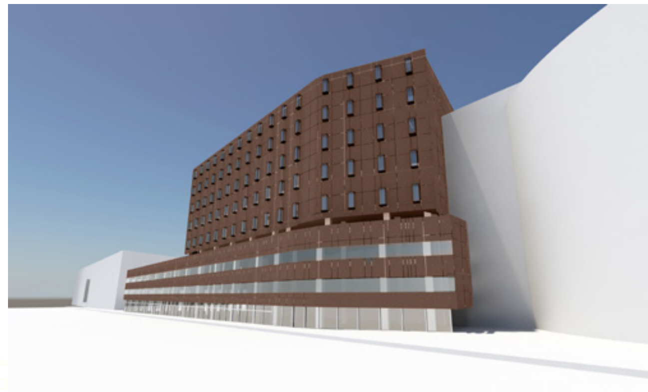
Coordination between the architect, structural, mechanical, and construction teams led to the implementation of the TERRART®-Large Terracotta Façade for the vertical wall system. The rear ventilated façade allows for air movement (the chimney effect) within the wall to optimize its energy efficiency. The façade protects against extreme temperatures maintain room conditions. The system is lightweight terracotta and is manufactured in custom panel sections for simple installation and replacement.

This lightweight facade provides support for high wind-load pressures and long spans. This façade is most commonly used on mainly concrete structures which is what Murex's design calls for making this project ideal for this façade selection. The connection to the super-structure is straightforward, and simplified even more with the provided NBK clip that comes with the purchase of this terracotta facade.



The construction of the facade provides a gas utility savings of over 23% compared to a simple concrete facade construction and provides a total energy building energy savings of 5%.

The energy consumption by the CHMC is about 60% better than the baseline typical hospital energy use in Climate Zone 5A (per ASHRAE), according to the NREL 2010 Edition. It is also about 15% better than the low-energy typical hospital baseline. More information for this can be seen in the mechanical supporting documents.



Smart Building Integration

The building has been equipped with the best control systems deemed for each situation presented. This includes healthcare specific security and management systems, the lighting control system, and the HVAC control system, among others. All of these are brought together through the DGLogik DGLux5 platform.

This system can monitor each of these systems and is completely customizable to the preference of the user. It is usable in a web browser or on a tablet or smartphone. This becomes an extremely valuable tool that can help address and fix problems before they arise. Additional, due to the sophistication of this system, it can track the energy savings that result throughout the building. Because these systems work together and many are available through smartphones, all of the staff's locations are continually tracked and can be reached quickly without delay if a necessary situation arises, such as Code Blue. It can also track all the equipment, patients, schedules, security access to ensure building safety and maximize operation by fully communicating with itself and being aware of itself.

Disaster Response Planning

In the event of loss of normal electrical power, the ventilation and pressure requirements for operating rooms, the intensive care units, the delivery rooms, trauma care rooms, and procedure rooms shall be maintained. This conforms with the provisions of NFPA 99, Standard for Health Care Facilities. When normal power is lost, the emergency generators will turn on providing power to the life safety, critical, and equipment branches to ensure safety for all occupants. The normal path of egress will be lit, triggered by fire alarms. A secondary path will be lit to the nearest tornado safe room if the building goes into a tornado lockdown. The emergency generators will be able to provide lighting and power will for each of these rooms for up to 48 hours should a disaster arise.

Murex's structural team is addressing this disaster response planning challenge by providing a FEMA tornado shelter in the basement of the building, as well as tornado safe rooms on each level of the structure. The FEMA tornado shelter in the basement will be the primary location in the event of a disaster. The safe rooms on each floor allow patients and other occupants a place to go if they are unable to relocate downstairs. Initial design considerations included the walls of these hardened structures on each floor as part of the lateral force resisting system. However, after considering Murex's goals of safety and integrity, we decided not to include these walls in that system. If these walls were part of the lateral system, then due to the rigidity of the walls, additional force would be directed at them in the event of a tornado, compromising the safety of the patients taking shelter there. The lateral system is instead made up of different walls and moment frames away from these areas, more details of which can be found in the structural narrative.

1.4.0 Design Criteria

Murex chose to design with safety, integrity, and sustainability as our driving factors. This aims to provide the best environment for the occupants and not detract from their comfort and well being while finding creative ways to be energy efficient.

Murex took into account the community of Omaha, Nebraska and CHMC when establishing our path to energy efficiency. In this region, energy efficiency and especially green building accreditation is not a precedence in design and construction. CHMC's mission and vision focus on the health and lives of their communities children and continuously improving the care and services that they can provide. Therefore, the design of CHMC focuses on enhancing the patient and occupant experience while optimizing how the building benefits the occupant. With this in mind, Murex approached the energy efficiency of the building with the focus to design to the highest efficiency that is cost effective and does not detract from the patient and occupant experience. Following this logic, Murex chose not to pursue LEED, WELL, and other efficiency based standards and certifications.

1.4.1 Codes and Standards

Murex's design complies with the minimum requirements set forth in the codes and standards used in our design. As a team we are committed to plan and design using best practice and having codes and standards as the baseline. The following codes and standards were used in the design of CHMC.

Structural
- 2015 IBC
- ASCE 7-10
- The City of Omaha Permits and Inspection Division - Engineering Data

Mechanical
- 2006 IMC
- 2000 LSC
- 2012 IFC
- ASHRAE Standard 62.1
- ASHRAE Standard 170
- 2013 ASHRAE Standard 90.1
- ASHRAE Standard 55
- ASHRAE Principle of Heating, Ventilation and Air-Conditioning, 7th Edition
- HVAC Design Manual for Hospitals and Clinics, 2nd Edition
- 2010 Closed-Loop/Geothermal Heat Pump Systems Design and Installations
- Closed-Loop Geothermal Systems Slinky Installation Guide
- 2015 Omaha Plumbing Code
- 2012 IPC
- 2012 IFGC
- 2015 NFPA 99, Standard for Health Care Facilities.
- 2016 NFPA 55
- FGI 2014 Guidelines for Design and Construction of Hospitals and Outpatient Facilities

Electrical
- 2009 IECC
- 2007 ASHRAE 90.1
- 2014 National Electrical Code
- 2010 NFPA-72
- IESNA 10th edition handbook

Construction
- OSHA Safety Standards

1.5.0 Project Research

The Murex team visited multiple sites throughout the design process leading to a better understanding of similar projects and ensuring the maximum delivery of the design goals.

1.5.1 Existing Facility and Site Visit

Murex's construction team and part of the structural took the time to visit the CHMC and the adjacent project site in the fall to better understand the site restrictions of the project.

1.5.2 Pediatric Hospital Tour

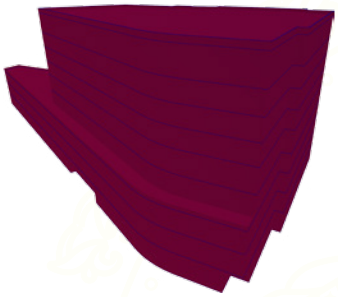
The mechanical and electrical teams arranged a private facility tour of a pediatric hospital with the in-house interior designer and engineer, along with the facility managers. They were able to provide details on best practice information, redundancy, and maintenance issues that are not always considered throughout the design. The team toured the central plant and penthouse, along with multiple different patient floors to better understand the balance between patient and safety priority and the best way to integrate the two while still being cost effective.

1.6.0 System Design Solutions

Murex collaborated throughout the design process to ensure that all integrated systems in CHMC will work together seamlessly. The team's design solutions are documented in the following sections.

1.6.1 Facade and Windows

Envelope



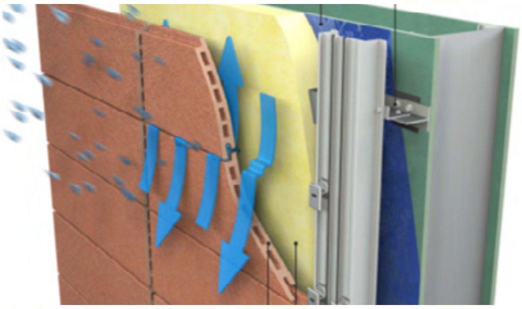
TThe mechanical team worked with the architect and the structural team to select the Terrart®-Large Terracotta Facade. The lightweight design simplifies the structural support for the system while still maintaining structural integrity. The rear ventilated facade allows for air movement (the chimney effect) within the wall to optimize the reduction in the envelope load. The facade protects the building envelope against extreme temperatures to maintain indoor conditions. The facade provides a maximum insulation barrier by eliminating the thermal bridge. The removal of the thermal bridge reduces the ability for the outdoor conditions to infiltrate the envelope. In cohesion with the removal of the thermal bridge, the chimney effect prevents moisture and mold development between the envelope layers. The facade also maximizes on a thermal shield design to protect the building from solar rays and extreme temperature and circulate room temperature air through the ventilated portion. As a result, the perimeter walls change temperature at a slower rate. As a whole, the proposed facade will provide energy savings for the entire building, which primarily stems from the reduced envelope load.

Another benefit to the terracotta facade is its low maintenance feature. The system is designed to perform and sustain with minimal effort by the owner. The self cleaning composition of the facade benefits both the occupant and the patients.

Glazing

Each patient room will have a window box that extrudes from the exterior. The occupants will be able to step into the extended box and be surrounded by views of the outdoors. The construction team provided integral design input in this architectural development. On the windows that do not pop out, motorized Mechoshades will be implemented to ensure glare is not a problem and that the occupant has the proper controls in order to create the most comfortable environment.

Patient Focused Design



The ventilated facade also promotes the health and safety of every occupant by maintaining thermal and hygrometric balance. The facade is designed to provide a filtration element to the exterior system. This reduces the contamination in the air surrounding CHMC benefitting both the occupants and community.

The window box design evolved from Murex's commitment to provide the best patient experience possible. The window creates a space where patients can escape the confinement of their rooms without leaving their safe environment behind. This promotes the recovery and well being of each patient and family.

1.6.3 Voided Slab System

An innovative aspect to the structural design is the implementation of a voided slab floor system. This floor system choice directly correlates with Murex's design goals through the following aspects:

The premise of a voided slab system is that instead of having a solid flat plate concrete slab, there would be recycled hollow plastic balls inside the slab, thus reducing the volume of concrete used and the overall weight of the slab. Due to the recycled material in the voids and the reduction of concrete used, this system encompasses sustainability in all aspects. Less concrete means less carbon dioxide released as well as implementing the voids allows for thinner slabs and a lower overall building height and materials.

Early coordination between the construction and structural teams and with the Cobiax, the manufacturer, allowed for the best design of this system. The construction team was able to locate the nearest concrete plant as well as the closest provider of the recycled plastic voids to create the most efficient, cost-effective implementation of this system. Understanding the construction process allowed the structural team to optimize the design with the best framing plan maximizing bay spacing and minimizing architectural disruptions.

1.6.3 Energy Foundation

Foundation

The structural foundation system for this building will be drilled piers. These piers will be 36 inches in diameter and will go down 89 feet below the slab on grade. Secant piles are also utilized to help keep the adjacent structure in tact while the new one is being built and allowed the decrease of the overall foundation wall thickness. In coordination with the construction team, Murex was able to create the most cost effective and efficient schedule to construct the foundation system.

Due to the existing structure being so close to the addition, the structural design had to implement cantilevered grade beams due to drilling restrictions for the piers and to reduce noise disturbance. Working with the construction team allowed the structural team to better understand the equipment and space needs to be able to actually install this foundation system. Moving the piers away from the existing structure in order to get the drilling equipment in a position to be able to drill the shafts and increase the safety of the construction process.

Integration of Geothermal Piles

A collaboration amongst the structural, mechanical, and construction teams led to the development of the spiral ground source loop incorporated into the drilled piers.

Geothermal energy is a reliable renewable resource that is acceptable for this midwestern location. A typical vertical geothermal system requires a large amount of excess earthwork, which is also a large expense. As the structural team is already planning to use structural piers for the foundation system at a depth of 89 feet below the finish floor elevation of Lower Level 5, Murex worked together to incorporate the vertical run as a spiral loop inside the rebar cage in the pier. This provided a renewable resource for cooling without requiring additional earthwork. This solution is called an energy pile or geothermal pile.

The ground source loop is connected to the refrigeration loop between the chillers and the cooling tower, to supplement the work of the cooling tower by using the earth as a heat sink.

Each energy pile extends 89 feet deep with a three foot diameter concrete structure that encases a vertical slinky run with a two foot diameter. Six inches of clearance is required form the edge of the pier to the geothermal piping.

The system's capacity can serve approximately 27% of the required heat exchange when the system runs at its peak cooling load by implementing this ground source loop strategy.

The cooling tower will provide the required heat exchange of the refrigerant that cannot be met by the ground loop to provide consistency and meet any future needs the hospital may produce.

1.6.4 Smart Building System

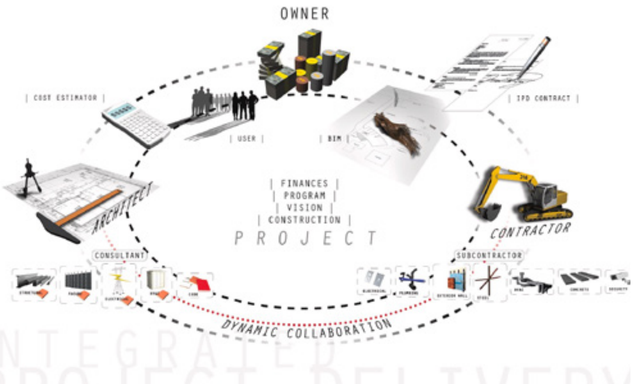
The importance of having a centralized location to track all information throughout the building was paramount. The system not only is able to bring in data from all different control systems throughout the building, but it can also analyze them and make suggestions for improvements between systems, if feasible. It is easily accessed by all staff personnel and can be customized to see only the information they wish to show in the manner which they wish to see it. The whole backbone of the system the patients and most occupants will never see, which is tracking of equipment, patients, doctors, and schedules for an efficiently run hospital, as well as other very technical information that building owners and operators will find valuable. It can also be turned into a learning tool, implemented at kiosks in lobbies and the home screen for each tv, where it can be chosen which data is shown from a central authoritative source in the hospital.

1.7.0 Integration

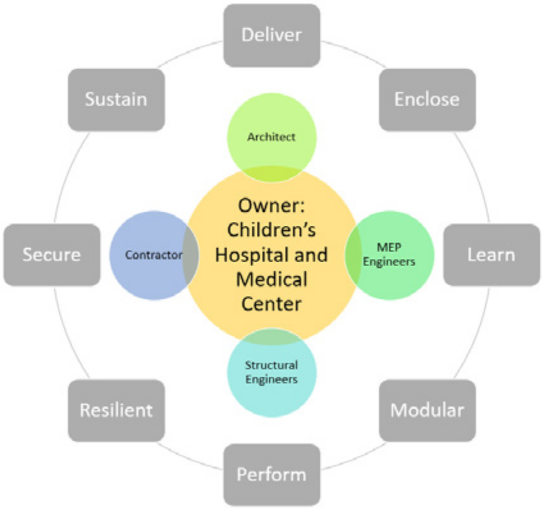
Murex team members effectively coordinated CHMC's design and construction by carrying out an Integrated Project Delivery (IPD) method.

1.7.1 Integrated Project Delivery

To quickly and efficiently deliver a project, Murex utilizes an IPD method. The IPD approach involves frequent communication among Murex's disciplines as the building system designs are developed. This method promotes constant coordination among all disciplines leading to a faster and more efficient design and construction process.



The team used the IPD method to ensure we were staying true to the AEI Build Initiatives. In meetings, members were reminded to keep these initiatives in mind when researching and developing the building systems and design.



The AEI Build Initiatives include eight areas of focus within the Architectural Engineering profession to aim to improve the design, maintenance, and construction of integrated buildings. While the Murex design works to incorporate all of these, through the goals set.

Weekly Team Meetings

Weekly team meetings were organized around each team members' schedule. They provided dedicated time to meet with all team members and advisors. During this time, each discipline asked and answered questions to help coordinate designs. These meetings allowed for Murex to develop our ideas for the design in each discipline and how to integrate them across the entire project

GroupMe

GroupMe is a mobile device application that simplifies group messaging. Advantages to using GroupMe in comparison to typical messaging platforms include but are not limited to, faster messaging, group member identifications, and cross-device compatibility. GroupMe offers a simple and instant path of communication for coordination between team members and disciplines.

Google Drive

Google Drive is a cloud based software intended for file storage, editing, and sharing that facilitated coordination and integration throughout the design process. Google Drive allows multiple users to edit a document at the same time without having to download or upload the document. This feature enabled team members to work simultaneously on files regardless of location.

Outlook Groups

Outlook Groups is an application for Windows Phone, Windows 10 Mobile, Android and iOS that can be used with an Office 365 domain Microsoft Account, e.g. a work or school account. It is designed to take existing email threads and turn them into a group-style conversation. The app lets users create groups, mention their contacts, share Office documents via OneDrive and work on them together, and participate in an email conversation. This provided for easy communication between team members and advisors.

1.7.2 Design Coordination

Throughout the design process, the communication between all disciplines is what improved our quality of work. Our team was able to create this innovative design under budget as a result.

Design Layout

The structural, mechanical, and electrical teams coordinate to verify equipment locations that will minimize vibration and improve system interaction. This is a major factor to accurately specify the voided slab sections. Penetration limitations are set based on the void locations. As a result, chase locations and potential penetration locations were verified early in the process after the structural team chose the voided slab system. The mechanical and electrical teams placed equipment in grouped locations to simply the process and were conscious of installation, maintenance, and replacement procedures as the life of the facility progresses.

The major equipment in the hospital is located far from patient rooms and procedure rooms to minimize disruption of patient and staff activities. Main duct runs will be located above coordinators whenever possible to prevent excess noise in these areas. Sound attenuators will be placed within the ductwork at identified problem areas. The concrete structure will aid in the reduction of sound due to the slab thickness between levels. Acoustic control is important to Murex's design because hospitals designed and constructed with reduced noise levels typically experience higher patient satisfaction due to the more comforting environment and improved sleep. These factors can lead to quicker healing times, which can mean shorter stays and reduced costs for both patients and hospitals. From a hospital employee perspective, a low-noise environment can increase job satisfaction, which could reduce employee turnover. All of these components influence the patient experience for which Murex is designing.

Vibration isolation plays a major role in the health of patients and staff, as controlling vibration impacting noise reduction. The concrete structure works to minimize any vibrations. In conjunction with the structural team, the mechanical and electrical teams placed the main equipment on Lower Level 5. Major floor mounted equipment on levels other than Lower Level 5 will be equipped with springs to control vibration. If site testing shows that additional isolation is necessary, self-leveling systems may be implemented.

Facade

The team chose the TERRART®-Large Terracotta Facade for CHMC for its versatility, lightweight structure, high wind resistance, strong insulating capabilities, and simplified installation process. These factors are influential in every aspect of design, and the team worked together to optimize design capabilities, provide the owner with options for external appearance, and be budget friendly.

Patient Needs

A hospital's role above all else is to serve its patients. CHMC plays a large role in the Omaha community, and the greater surrounding communities, through healthcare offerings and employment opportunities and as community symbol for health and safety. As a team, we decided this was our focus.

Our design allows for individualized patient comfort through individualized temperature and lighting control, a large overhang window in each patient room, a safety plan in case of environment emergencies or other threats. Air is highly filter to improve air quality and minimize the spread of infection. The facility has an outdoor garden area on roof at Level 2 that allows both patients and employees to escape the indoors and enjoy the fresh air.

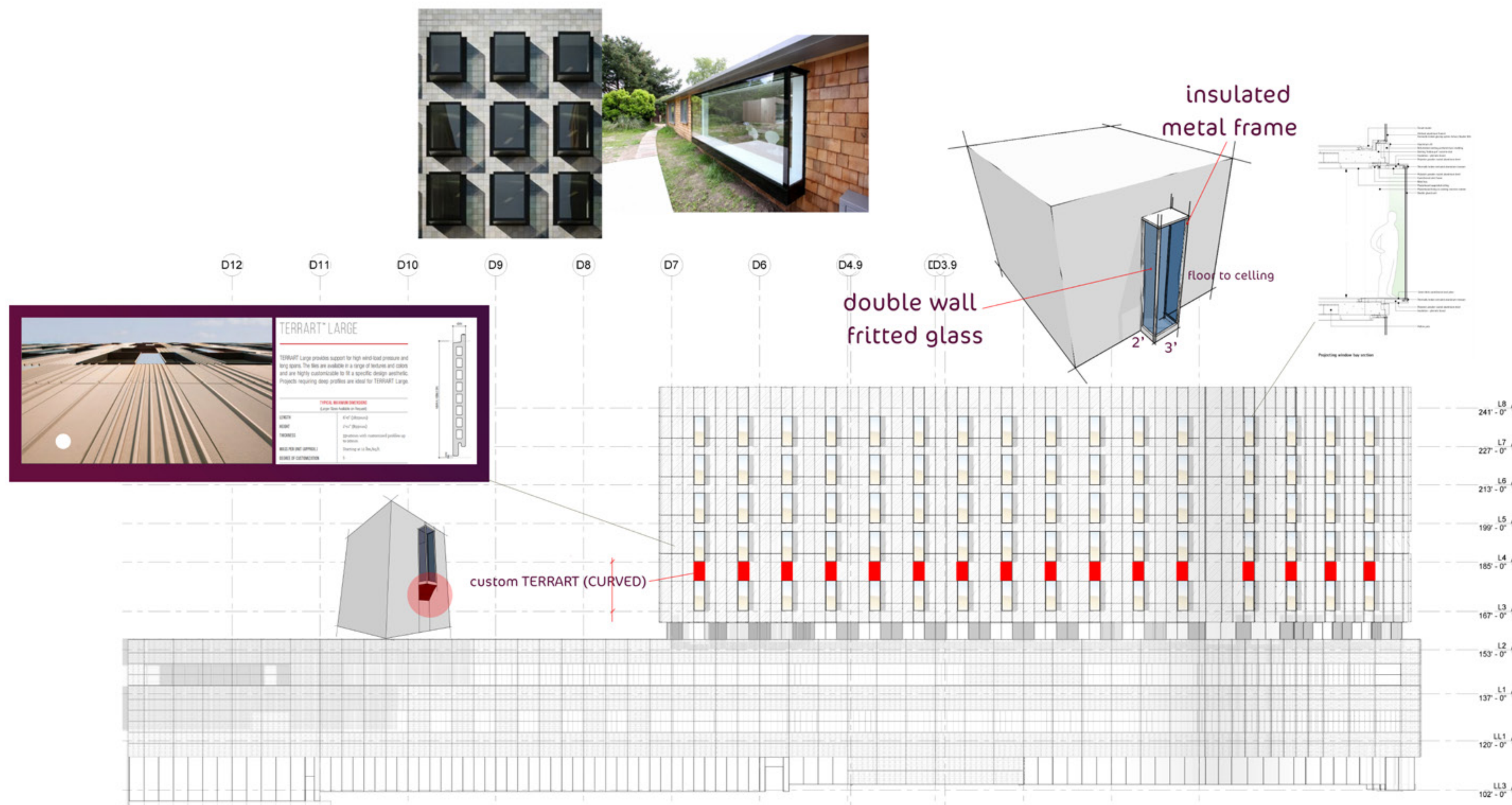
Through coordination with the construction team, the project is able to come in $50 million under budget and be completed in approximately 34 months. This gives the board members of the hospital an opportunity to allocate that funding to additional requests on this project or invest in other campus advancements or renewable energy sources, or even a fund for patients who receive care at CHMC. This flexibility results from the design team's choice to passover LEED, WELL, and Living Building Challenge design standards at this level of DD yet still provide an energy efficient design.

1.8.0 Conclusion

Murex established a cohesive and collaborative design development that evolved through communication and cooperation of a multi-discipline team. As a team, a high performance design solution for Children's Hospital and Medical Center of Omaha was promoted through integration of each discipline that made the compiled design more valuable than its individual components on their own. By focusing on a Integrated Project Delivery method, Murex efficiently delivered a most desired and cohesive design. Conclusively, Murex produced a comprehensive design that provides CMHC and the community of Omaha with a high quality project that adds value through enhanced performance and operation. The project promotes a standard of design though safety, integrity, and sustainability.

	EXECUTING									INFLUENCING								RELATIONSHIP BUILDING									STRATEGIC THINKING							
Name of Team Member	Achiever	Arranger	Belief	Consistency	Deliberative	Discipline	Focus	Responsibility	Restorative	Activator	Command	Communication	Competition	Maximizer	Self-Assurance	Significance	Woo	Adaptability	Connectedness	Developer	Empathy	Harmony	Includer	Individualization	Positivity	Relator	Analytical	Context	Futuristic	Ideation	Input	Intellection	Learner	Strategic
Team Leader, MEP Member 1									x		x												x	x							x			
MEP Member 2								x	x																	x	x						x	
MEP Member 3				x				x				x									x							x						
Structural Member 1										x											x		x			x								x
Structural Member 2			x												x		x					x											x	
Structural Member 3							x																x		x	x							x	
Construction Member 1				x								x						x							x								x	
Construction Member 2				x							x	x													x									x
Construction Member 3				X								X													X									
Architect/Graphic Designer																																	X	

Murex Hospital Design Inspiration from the Institute of Medicine's report, *Crossing the Quality Chasm: A New Health System for the 21st Century*:	
Patient-centeredness	using variable-acuity rooms and single-bed rooms ensuring sufficient space to accommodate family members enabling access to health care information having clearly marked signs to navigate the hospital
Safety	applying the design and improving the availability of assistive devices to avert patient falls using ventilation and filtration systems to control and prevent the spread of infections using surfaces that can be easily decontaminated facilitating hand washing with the availability of sinks and alcohol hand rubs preventing patient and provider injury addressing the sensitivities associated with the interdependencies of care, including work spaces and work processes
Effectiveness	use of lighting to enable visual performance use of natural lighting controlling the effects of noise
Efficiency	standardizing room layout, location of supplies and medical equipment minimizing potential safety threats and improving patient satisfaction by minimizing patient transfers with variable-acuity rooms
Timeliness	ensuring rapid response to patient needs eliminating inefficiencies in the processes of care delivery facilitating the clinical work of nurses
Equity	ensuring the size, layout, and functions of the structure meet the diverse care needs of patients



VOIDED SLAB DESIGN

Self-Weight of Voided Slab

$V_{void} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(5")^3 = 523\ in^2$

$V_{total} = (14")(11")(11") = 1694\ in^2$

% Concrete Savings = 30.9 %

Equivalent Slab Thickness = (14")(1 - 0.309) = 9.68"

D = (150 PCF)(1 ft)(9.68/12 ft) = 121.0 PSF

Determine Tota Factored Static Moment in Each Span

$w_u = 1.2D + 1.6L = 1.2(120.9 + 20) + 1.6(50) = 249.1\ PSF$

$l_n = 32' - 4' = 28'$

$M_0 = \frac{w_u l_2 l_n^2}{8} = \frac{(249.1\ PSF)(33')(28')^2}{8} = 805.6\ k - ft$

Location			M_u (k-ft)	A_s (in^2)	Reinf.
End Span	Column Strip	Exterior Negative	209.5	4.84	11 # 6
		Positive	249.7	4.84	11 #6
		Interior Negative	427.0	7.92	18 #6
	Middle Strip	Exterior Negative	0.0	4.84	11 #6
		Positive	169.2	4.84	11 #6
		Interior Negative	137.0	4.84	11 #6
Interior Span	Column Strip	Positive	169.2	4.84	11 #6
		Negative	394.7	7.48	17 #6
	Middle Strip	Positive	112.8	4.84	11 #6
		Negative	128.9	4.84	11 #6

Required Reinforcement

d = 14" - 1.25" = 12.75" b = 192"

$R_n = \frac{M_u}{\phi b d^2} = \frac{(427.0\ k - ft)(1000\frac{lb}{k})(12"/ft)}{0.9(192")(12.75")^2} = 182.4\ psi$

$\rho = \frac{0.85 f'_c}{f_y}\left[1 - \sqrt{1 - \frac{2Rn}{0.85 f'_c}}\right] = \frac{0.85(4)}{60}\left[1 - \sqrt{1 - \frac{2(182.4)}{0.85(4000)}}\right] = 0.0031$

$A_s = \rho bd = (0.0031)(192")(12.75") = 7.65\ in^2$

$A_{s\ min} = 0.0018bh = 0.0018(192")(14") = 4.84\ in^2$

Check Compression Block

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(7.65)(60)}{0.86(4)(192)} = 0.703"$

$c = \frac{a}{\beta_1} = \frac{0.703}{0.85} = 0.828" < 2"$ → GOOD

$\varepsilon_t = 0.003\left(\frac{d}{c} - 1\right) = 0.003\left(\frac{12.75}{0.828} - 1\right) = 0.0432$

Choose Reinforcement

→ USE **(18) #6 BARS**

$A_s = 7.92\ in^4$

Check Spacing at Critical Sections

$c_2 + 3h = 36" + 3(14") = 78"$

$b_1 = c_1 + \frac{d}{2} = 36" + \frac{12.75"}{2} = 42.375"$

$b_2 = c_2 + d = 36" + 12.75" = 48.75"$

$\gamma_f = \frac{1}{1 + (\frac{2}{3})(\sqrt{b_1/b_2}} = 0.62$

$\gamma_f M_u = 0.62(209.5) = 129.9\ k - ft$

Use Minimum Reinforcement → 11 #6 Bars

78"/11 = 7.1" < 18" → OK

Two-Way Shear Design Capacity

$\phi V_c = \phi 4\lambda\sqrt{f'_c}b_0 d$

$= 0.75(4)(1.0)\sqrt{4000}[4(36 + 12.75)](12.75)\left(\frac{1}{1000}\right)$

$= 471.7\ k$

Solid Area Around Column

$A_{solid} = Tributary\ Area\ of\ Column - \frac{(Shear\ Reduction\ Factor)(Allowable\ Direct\ Shear\ Force)}{Total\ Factored\ Uniformly\ Distributed\ Load}$

$= (32' x\ 33') - \frac{(0.55)(471.7\ k)}{(0.2491\ ksi)} = 14.5\ ft^2$

Total Factored Sheared Stress

$V_u = qu(A_t - b_1 b_2)$

$= (0.249\ k)\left(560ft^2 - (42.375")(48.75")\left(\frac{1}{144}\right)\right) = 135.9\ k$

$A_t = \frac{32'}{2} + \frac{36"}{2\left(\frac{12"}{ft}\right)} = 560\ ft^2$

$\gamma_v = 1 - \gamma_f = 1 - 0.62 = 0.38$

$0.3M_0 = Mu = 0.3(781\ k - ft) = 234.3\ k - ft$

$J_c c_{AB} = \frac{2b_1^2 d(b_1 + 2b_2) + d^3(2b_1 + b_2)}{6b_1} = 26{,}279\ in^3$

$v_u = \frac{V_u}{A_c} + \frac{\gamma_v M_u}{J_c c_{AB}} = \frac{135.9}{1702} + \frac{0.38(234.3)(12)}{26{,}279} = 120.5\ psi$

Allowable Shear Stress

$\phi V_c = \phi 4\lambda\sqrt{f'_c} = (0.75)(4)(1.0)\sqrt{4000} = 189.7\ psi$

$v_u < \phi V_c$ → OK

VOIDED SLAB DESIGN: MECHANICAL ROOM

Self-Weight of Voided Slab

$V_{void} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(5")^3 = 523\ in^2$

$V_{total} = (14")(11")(11") = 1694\ in^2$

% Concrete Savings = 30.9 %

Equivalent Slab Thickness = (14")(1 - 0.309) = 9.68"

D = (150 PCF)(1 ft)(9.68/12 ft) = 121.0 PSF

Determine Tota Factored Static Moment in Each Span

$w_u = 1.2D + 1.6L = 1.2(120.9 + 20) + 1.6(125) = 369.1\ PSF$

$l_n = 32' - 4' = 28'$

$M_0 = \frac{w_u l_2 l_n^2}{8} = \frac{(369.1\ PSF)(33')(28')^2}{8} = 1193.6\ k - ft$

Location			M_u (k-ft)	A_s (in^2)	Reinf.
End Span	Column Strip	Exterior Negative	-310.3		
		Positive	370.0		
		Interior Negative	-632.6	7.92	18 #6
	Middle Strip	Exterior Negative	0.0		
		Positive	250.7		
		Interior Negative	-202.9		
Interior Span	Column Strip	Positive	250.7		
		Negative	-584.9		
	Middle Strip	Positive	167.1		
		Negative	-191.0		

Required Reinforcement

d = 14" - 1.25" = 12.75" b = 192"

$R_n = \frac{M_u}{\phi b d^2} = \frac{(632.6\ k - ft)(1000\frac{lb}{k})(12"/ft)}{0.9(192")(12.75")^2} = 270.2\ psi$

$\rho = \frac{0.85 f'_c}{f_y}\left[1 - \sqrt{1 - \frac{2Rn}{0.85 f'_c}}\right] = \frac{0.85(4)}{60}\left[1 - \sqrt{1 - \frac{2(270.2)}{0.85(4000)}}\right] = 0.0047$

$A_s = \rho bd = (0.0047)(192")(12.75") = 11.50\ in^2$

$A_{s\ min} = 0.0018bh = 0.0018(192")(14") = 4.84\ in^2$

Check Compression Block

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(11.5)(60)}{0.86(4)(192)} = 1.045"$

$c = \frac{a}{\beta_1} = \frac{1.045}{0.85} = 1.23" < 2"$ → OK

$\varepsilon_t = 0.003\left(\frac{d}{c} - 1\right) = 0.003\left(\frac{12.75}{1.23} - 1\right) = 0.0281$

Choose Reinforcement

→ USE **(27) #6 BARS**

$A_s = 11.88\ in^2$

Check Spacing at Critical Sections

$c_2 + 3h = 36" + 3(14") = 78"$

$b_1 = c_1 + \frac{d}{2} = 36" + \frac{12.75"}{2} = 42.375"$

$b_2 = c_2 + d = 36" + 12.75" = 48.75"$

$\gamma_f = \frac{1}{1 + (\frac{2}{3})(\sqrt{b_1/b_2}} = 0.62$

$\gamma_f M_u = 0.62(310.3) = 192.4\ k - ft$

Use Minimum Reinforcement → 11 #6 Bars

78"/11 = 7.1" < 18" → OK

Two-Way Shear Design Capacity

$\phi V_c = \phi 4\lambda\sqrt{f'_c}b_0 d$

$= 0.75(4)(1.0)\sqrt{4000}[4(36 + 12.75)](12.75)\left(\frac{1}{1000}\right)$

$= 471.7\ k$

Solid Area Around Column

$A_{solid} = Tributary\ Area\ of\ Column - \frac{(Shear\ Reduction\ Factor)(Allowable\ Direct\ Shear\ Force)}{Total\ Factored\ Uniformly\ Distributed\ Load}$

$= (32' x\ 33') - \frac{(0.55)(471.7\ k)}{(0.3691\ ksi)} = 353\ ft^2$

Total Factored Sheared Stress

$V_u = qu(A_t - b_1 b_2)$

$= (0.369\ k)\left(560ft^2 - (42.375")(48.75")\left(\frac{1}{144}\right)\right) = 201.3\ k$

$A_t = \frac{32'}{2} + \frac{36"}{2\left(\frac{12"}{ft}\right)} = 560\ ft^2$

$\gamma_v = 1 - \gamma_f = 1 - 0.62 = 0.38$

$0.3M_0 = Mu = 0.3(1193.6\ k - ft) = 358.1\ k - ft$

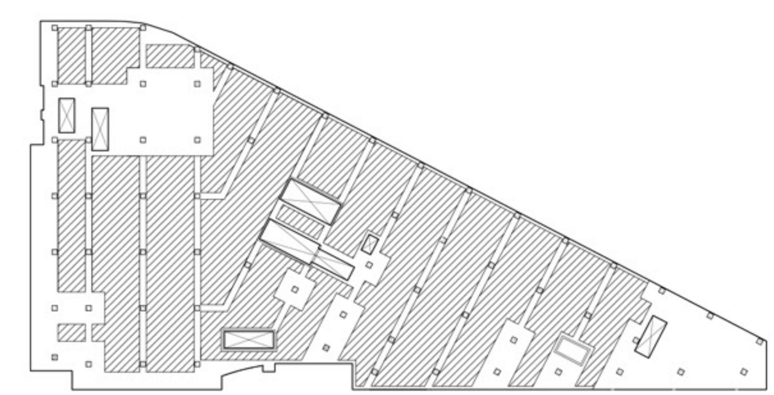
$J_c c_{AB} = \frac{2b_1^2 d(b_1 + 2b_2) + d^3(2b_1 + b_2)}{6b_1} = 26{,}279\ in^3$

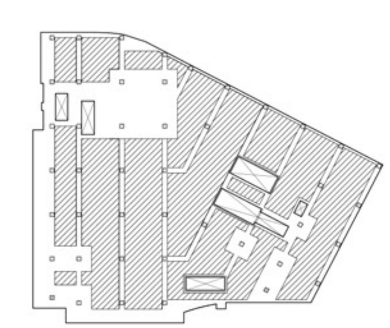
$v_u = \frac{V_u}{A_c} + \frac{\gamma_v M_u}{J_c c_{AB}} = \frac{201.3}{1702} + \frac{0.38(234.3)(12)}{26{,}279} = 158.9\ psi$

Allowable Shear Stress

$\phi V_c = \phi 4\lambda\sqrt{f'_c} = (0.75)(4)(1.0)\sqrt{4000} = 189.7\ psi$

$v_u < \phi V_c$ → OK





VOIDED SLAB

DRILLED PIER DESIGN

Step Description	Calculations	Reference
Parameters	**Column Parameters:** Size: 36" ϕ; D: 36 in; Pipe Area: 54.75 in²; Gross Area: 1017.36 in²; Net Area: 962.61 in². Properties: f'c = 6,000 psi; fy = 60,000 psi; Es = 29,000 psi; Maximum Concrete Strain ε_{max} = 0.003 in/in	
Determine Reinforcement	Transverse Reinforment: #3 @16" O.C.; Longitudinal Renforcement: 9 #10; $Area_{bar}$ = 1.27 in²; $Area_{provided}$ = 11.43 in²; Area concrete = 951.18 in². Clear Cover = 2.5 in; Edge Distance= 3.135 in; Spacing = 10.32 in; $A_{s\,min} = A_{gross}(0.01)$; $A_{s\,min} = (1018\,in^2)(0.01)$; $A_{s\,min}$ = 10.1736 in²	
Analysis	**Axial Capcity:** (Pure Axial) $\emptyset P_n = \emptyset[(0.85)(f'_c)(A_g - A_s) + (A_s f_y)]$ $\emptyset = 0.7\ (Tied)$; $\emptyset P_n = 0.7[(0.85)(10{,}000\,psi)(1296\,in^2 - 15.6\,in^2) + (15.6\,in^2)(60{,}000\,psi)]$; $\emptyset P_n$ = 3875.76 kips; Reducation of Axial Capacity = $(0.8)\emptyset P_n$ = 3100.61 kips	
	Moment Capacity: Area of Rebar = 1.27 in²; $a = \frac{(A_s)(f_y)}{(0.85)(f'_c)(d)}$; $a = \frac{(1.27\,in^2)(9\,Bars)(60{,}000\,psi)}{(0.85)(6{,}000\,psi)(36\,in)}$; a = 3.735 in; $M_n = (A_s)(f_y)\left[d_1 - \left(\frac{a}{2}\right)\right]$; $M_n = (1.27\,in^2)(9\,Bars)(60{,}000\,psi)\left[32.9\,in - \left(\frac{3.375\,in}{2}\right)\right]$; M_n = 1771.50 kip-ft; $\emptyset M_n = (0.9)(1771.5\,k-ft)$; $\emptyset M_n$ = 1594.35 kip-ft	

SHEAR WALL DESIGN

1. Initial Check of Wall Reinforcement

$$\rho_t = \frac{A_{v\,horiz}}{hs_2} = \frac{2(0.2\,in^2)}{(14")(18")} = 0.0016$$

$$\rho_l = \frac{A_{v\,vert}}{hs_1} = \frac{2(1.0\,in^2)}{(14")(12")} = 0.0119$$

2. Check Moment Strength

$$M_{base} = 14{,}653\,k-ft$$

$$M_u = 0.9D + 1.0W$$

$$M_u = 1.0(14{,}653\,k-ft) = 14{,}653\,k-ft$$

$$N_u = 0.9ND = 0.9(747.4\,k) = 672.7\,k$$

$$w = pl\frac{f_y}{f'_c} = (0.0119)\left(\frac{60}{8}\right) = 0.0893$$

$$\alpha = \frac{N_u}{hl_w f'_c} = \frac{672.7\,k}{(14)(186)(8\,ksi)} = 0.0323"$$

$$c = \left(\frac{\alpha + w}{0.85\beta_1 + 2w}\right)l_w = \left(\frac{0.0323 + 0.0893}{0.85(0.65) + 2(0.0893)}\right)(186") = 30.9"$$

$$d = 0.8lw = 0.8(186) = 148.8" \rightarrow c < 0.375d \rightarrow tension - controlled\ section$$

$$A_{st} = 2Ab\frac{l_w}{s_1} = 2(1.0\,in^2)\frac{186"}{12"} = 31.0\,in^2$$

$$T = Astf_y\left(\frac{l_w - c}{l_w}\right) = (31.0\,in^2)(60\,ksi)\left(\frac{186" - 30.9"}{186"}\right) = 1551\,k$$

$$M_n = T\left(\frac{l_w}{2}\right) + Nu\left(\frac{l_w - c}{l_w}\right) = (1551\,k)\left(\frac{186"}{2}\right) + (673\,k)\left(\frac{186" - 30.9"}{186"}\right) = 16{,}370\,k-ft$$

$$\phi M_n = 0.9(16{,}370\,k-ft) = 14{,}733\,k-ft > Mu = 14{,}653\,k-ft$$

3. Check Shear Strength

$$V_{base} = 147\,k$$

$$V_u = 0.9D + 1.0W = 1.0(147\,k) = 147\,k$$

$$V_c = 3.3\lambda\sqrt{f'_c}hd + \frac{N_u d}{4lw} = 3.3(1.0)\sqrt{8000\,psi}(14")(148.8") + \frac{(672.7\,k)(148.8")}{4(186")} = 749.5\,k$$

Critical Section Above Base of Wall

Smallest of: $\frac{l_w}{2} = 7.75'$ $(GOVERNS)$

$\frac{h_w}{2} = 82.5'$

$One - Story\ Height = 22'$

$$M_{u(crit)} = Mu_{(base)} - Vu_{(base)}\frac{l_w}{2} = (14{,}653\,k-ft) - (147\,k)\frac{15.5\,ft}{2} = 13{,}514\,k-ft$$

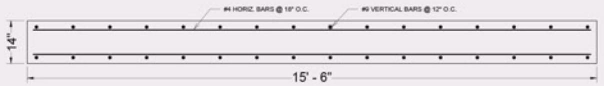
$$\frac{M_u}{V_u} = \frac{13{,}514\,k-ft}{147\,k} = 91.9\,ft$$

$$V_c = \left[0.6\lambda\sqrt{f'_c} + \frac{l_w\left(1.25\lambda\sqrt{f'_c} + 0.2\frac{N_u}{l_w h}\right)}{\frac{M_u}{V_u} - \frac{l_w}{2}}\right]hd = 174.5\,k$$

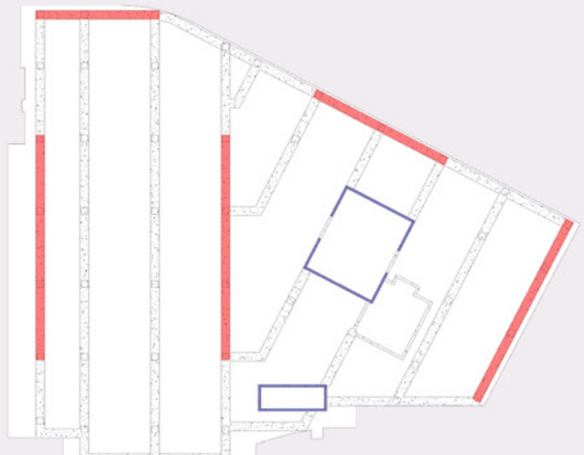
$$\phi V_c = 0.75(174.5\,k-ft) = 130.9\,k < Vu = 147\,k$$

$$V_{s\,equiv} = \frac{A_{v\,horiz}f_{yt}l_w}{s_2} = \frac{2(0.2\,in^2)(60\,ksi)(186")}{18"} = 248\,k$$

$$\phi V_n = \phi(V_c + Vs) = 0.75(174.5\,k) = 317\,k$$



MOMENT FRAME
SHEAR WALL



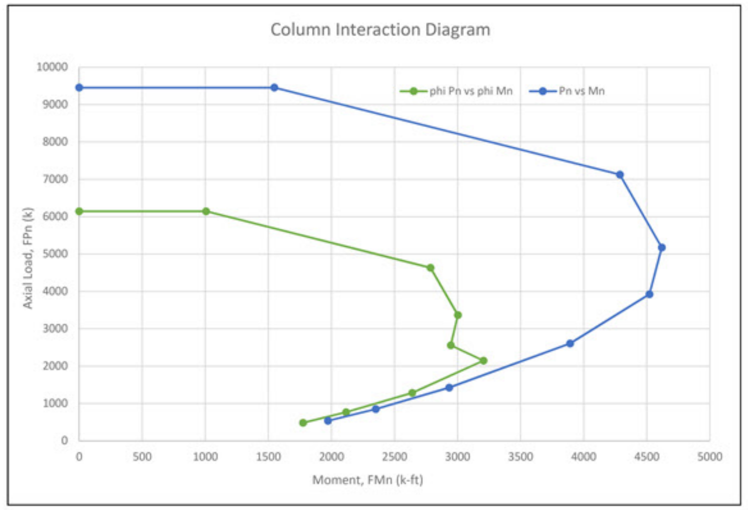
REINFORCED CONCRETE COLUMN DESIGN

Step Description	Calculations
Known Information	**Column Parameters:** Size: 36" x 36"; B: 36 in; H: 36 in; Total Area: 1296 in²; Transverse Reinforment: #4; Longitudinal Renforcement: 10#11; Area = 1.56 in²; $Area_{provided}$ = 15.6 in²; Gross Area = 1280.4 in²; Layout of Column: D1: 33.5 in; D2: 23.17 in; D3: 12.83 in; D4: 2.50. Properties: f'c = 10,000 psi; fy = 60,000 psi; Es = 29,000 psi; Maximum Concrete Strain ε_{max} = 0.003 in/in; Edge Distance = 2.5 in; Spacing = 10.33 in; $A_{s\,min} = A_{net}(0.01)$; $A_{s\,min} = (1296\,in^2)(0.01)$; $A_{s\,min}$ = 12.96 in²
Analysis	**Axial Capcity:** (Pure Axial) $\emptyset P_n = \emptyset[(0.85)(f'_c)(A_g - A_s) + (A_s f_y)]$ $\emptyset = 0.7\ (Tied)$; $\emptyset P_n = 0.7[(0.85)(10{,}000\,psi)(1296\,in^2 - 15.6\,in^2) + (15.6\,in^2)(60{,}000\,psi)]$; $\emptyset P_n$ = 8273.58 kips; Reducation of Axial Capacity = $(0.8)\emptyset P_n$ = 6618.86 kips
	Moment Capcaity: Area of Rebar = 1.56 in²; $a = \frac{(A_s)(f_y)}{(0.85)(f'_c)(B)}$; $a = \frac{(1.56\,in^2)(3\,Bars)(60{,}000\,psi)}{(0.85)(10{,}000\,psi)(36\,in)}$; a = 0.918 in; $M_n = (A_s)(f_y)\left[d_1 - \left(\frac{a}{2}\right)\right]$; $M_n = (1.56\,in^2)(3\,Bars)(60{,}000\,psi)\left[33.5\,in - \left(\frac{0.918\,in}{2}\right)\right]$; M_n = 773.16 kip-ft; $\emptyset M_n = (0.9)(773.16\,k-ft)$; $\emptyset M_n$ = 695.85 kip-ft

Interaction Diagram

Interaction Diagram Data

ε_s	Pn	Mn	Φ	ΦP_n	ΦM_n
	k	k-ft		k	k-ft
-0.003	-11,819	0	0.650	-7,683	0
-0.001	-10,649	-1,547	0.650	-6,922	-1,006
0.000	-7,127	-4,286	0.650	-4,632	-2,786
0.00103	-5,178	-4,619	0.650	-3,366	-3,002
0.00207	-3,926	-4,520	0.652	-2,559	-2,946
0.00414	-2,609	-3,892	0.823	-2,148	-3,205
0.00828	-1,426	-2,934	0.900	-1,283	-2,640
0.01241	-852	-2,351	0.900	-767	-2,116
0.0166	-536	-1,972	0.900	-483	-1,775



Energy Comparsion Calculation

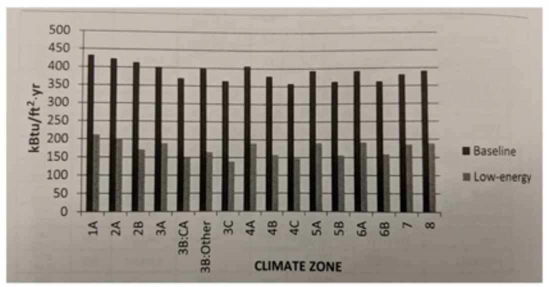
	Total Source Energy	Total Building Energy	Electric Consumption	Gas Consumption
TERRART Facade	134172448	48862418	12448735	6381711
Simple Constrcution Facade	136671488	50944661	12492949	8306226
Percent Better	1.83%	4.09%	0.35%	23.17%

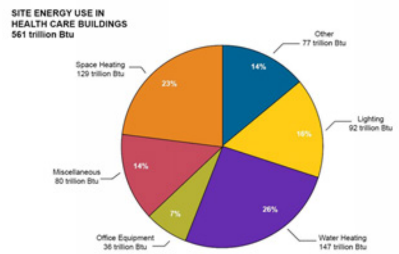
***The Trane Trace calculations for energy consumption did not include all aspects of hospital energy usuage. The areas accounted for are lighting, office equipment, space heating, and a mixture of miscellaneous loads. To account for the other loads, the pi graph below was used.

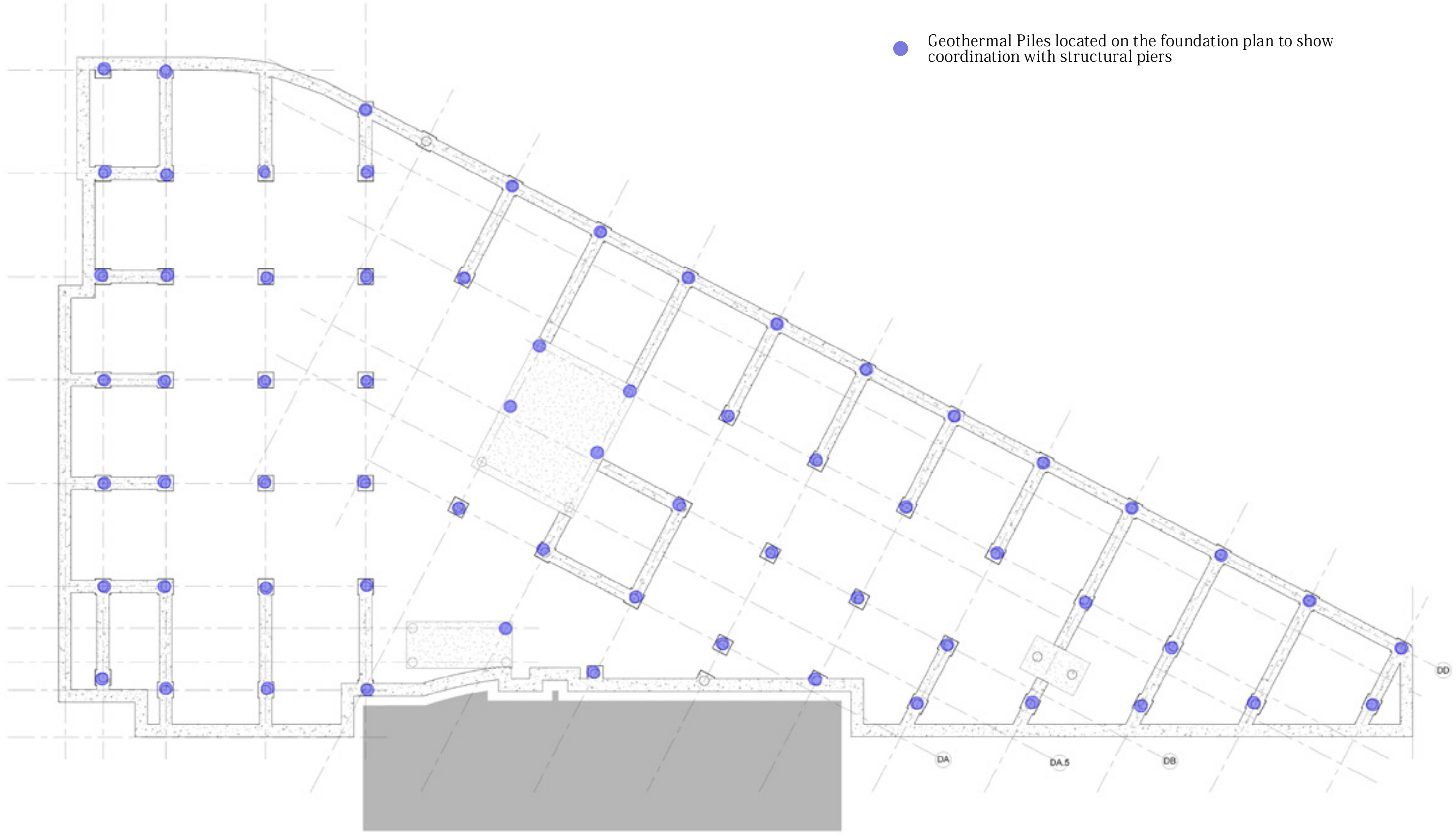
Accounts for ~ 60%

Total Enery Loads Coparison for Climate 5A

	Omaga CHMC Facility	Baseline	Low Energy
Energy Load	68407385.2	200000000	95000000
Percent Better	-----	65.80%	27.99%







DUAL RUN VERTICAL GROUND LOOP IN STRUCTURAL PIER

1 ton = ~200ft of linear pipe	
89 ft piers	
65 piers total	
89ft/pier x 65 piers =	5785 total linear ft of pipe
5785 ft x 1 ton / 200 ft =	~ 30 tons
Assume dual run of pipe in each pier	
2 x 30 tons =	~60 tons
Peak Cooling Load	1027 tons
Percentage of Building Load Provided	
60 tons / 1027 tons =	5.5 %

SLINKY RUN GROUND LOOP IN STRUCTURAL PIER

Lp = use equation 1.2

Nl =	108.75	
Ll =	6.28	ft
d =	2	ft
P =	0.8	ft
Lt = (Nl * P) + d	89	ft

Lp = (108.75)x(6.28)+(108.75)x(2 x 0.8) + (2pi)/2 +2

Lp =	863	ft per slinky run
65 piers x 862 ft =	56030 total linear ft of pipe	
56030 ton / 200ft/ton =	280.15 tons	

Percentage of Building Load Provided
280.15 tons / 1027 tons = 27 %

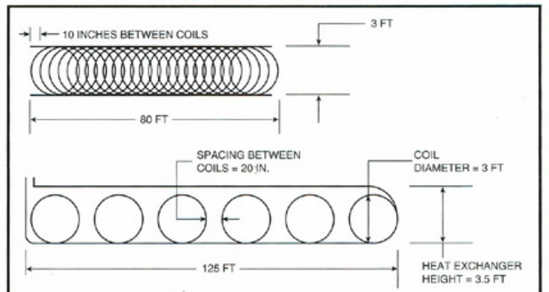


FIGURE 1.2: Multiple-Pipe Ground Heat Exchangers

Equation 1.1
Lp = Nl • Ll + Nl • 2P + πd/2 + d

Equation 1.2
Nl = [Lp – d(π/2 + 1.0)] / (Ll + 2P)

where:
Lp = Pipe length (ft)
Nl = Number of loops
Ll = Length of loop (ft)(circumference) = π • d = 3.14159 • d
P = Pitch or spacing (ft)
d = Loop diameter (ft)
L(t – h) = Length from end of basic trench to header (ft)

Lt = (Nl • P) + d
Lt = Trench length (ft)
Lt + L(t – h) = Total trench length
Lp + 2 • L(t – h) = Total pipe length

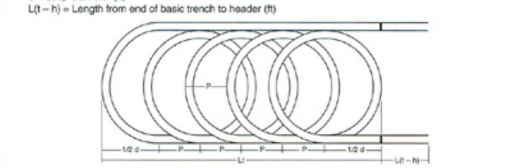


FIGURE 1.1: Nomenclature for Slinky Tables

DGLux5

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DGLux5, our "drag & drop" rapid application development and visualization platform enables individuals and teams to design real time, data driven applications and dashboards without ever writing a single line of code. It maximizes analysis efficiency and enables faster communication through real time, data driven dashboards for web, desktop and mobile devices. Significantly reduce time and money in project design, creation and deployment with a modern platform that everybody loves, DGLux5.

Link Various Data

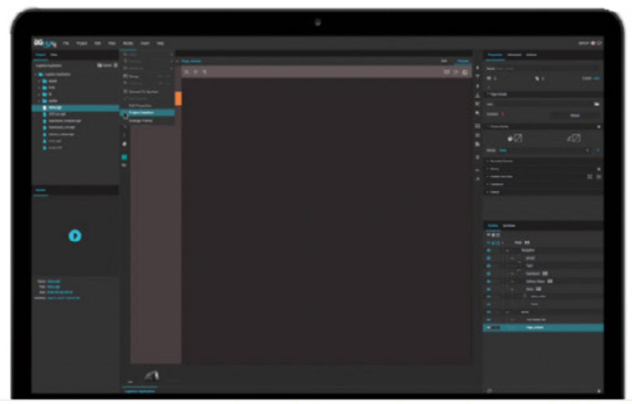
Gain access to all your data sources in a single, unified workspace. Derive information from any database, iot device, social media platform, etc.

Control & Command Data

Revolutionizing the way we build applications through visual programming, DGLux provides the tools for controlling & commanding your data!

Drag & Drop Data Binding

The data-to-property and property-to-property binding flexibility within DGLux5 is amazing but having a full drag and drop environment that drives that flexibility is absolutely stunning.



Create Personalized Interaction

Create personalized interaction by adding behaviors to any object using the "Record State" feature which allows you to change parameters and automatically save the recorded changes as behaviors. This enables you to execute commands through any possible user interaction, creating unique, sophisticated interfaces and experiences.

Set Mouse Gestures

To build interactive applications, DGLux allows you to add behaviors to any objects interaction a user can make such as click, double click, roll over, rollover & out, mouse down, mouse up, click on, click off, load complete or custom triggers for a mix of interactions.

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DGLux enables you to build interactive mobile applications with support for all touch screen gestures such as swipe, rotate, pinch, spread, two finger tap and scroll

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Create logic sequences within our advanced, visual programming User Interface...without having to write any script!

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Data Connections Available

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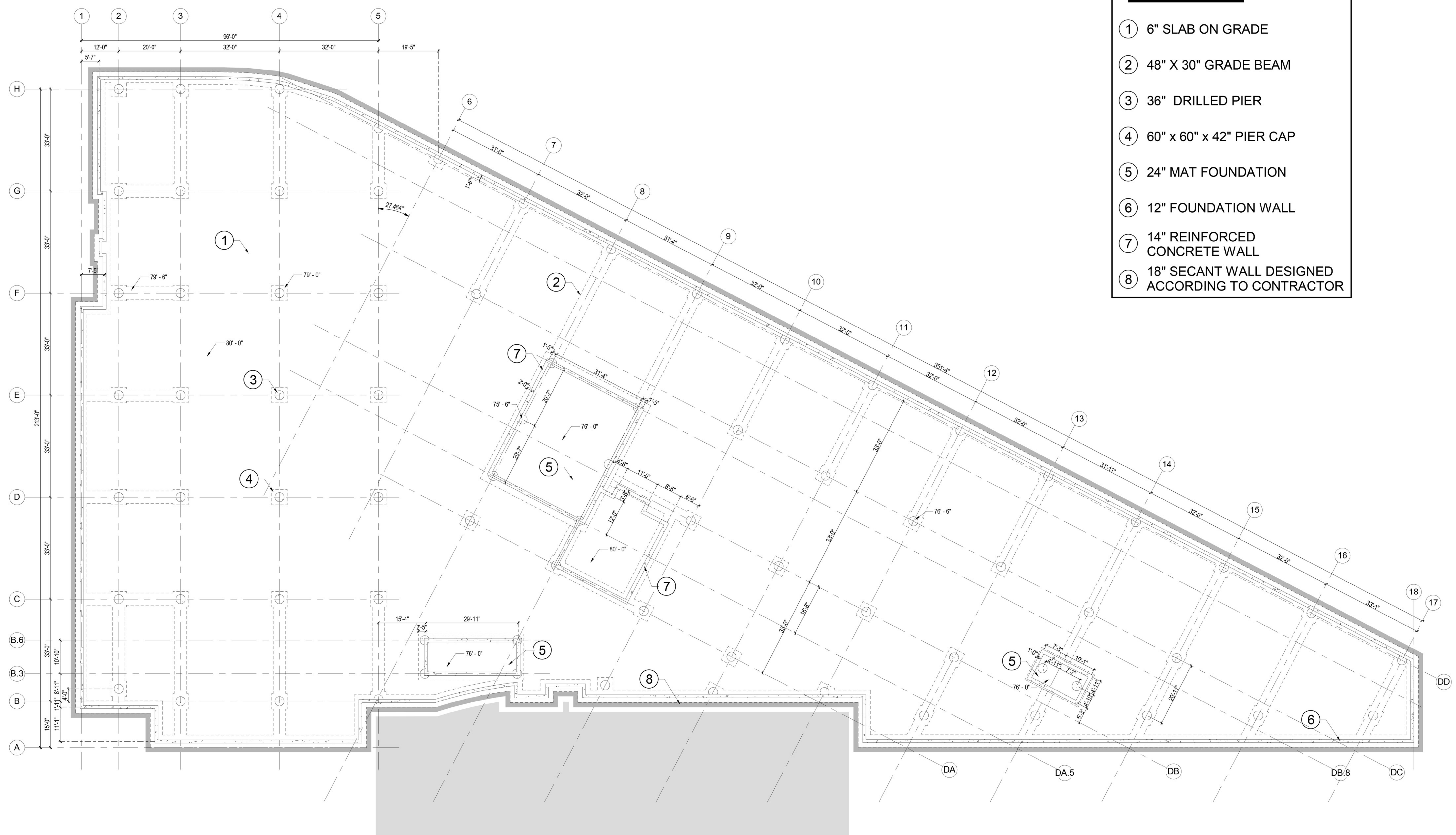


LEGEND:

1. 6" SLAB ON GRADE
2. 48" X 30" GRADE BEAM
3. 36" DRILLED PIER
4. 60" x 60" x 42" PIER CAP
5. 24" MAT FOUNDATION
6. 12" FOUNDATION WALL
7. 14" REINFORCED CONCRETE WALL
8. 18" SECANT WALL DESIGNED ACCORDING TO CONTRACTOR

A
S-101

FOUNDATION PLAN

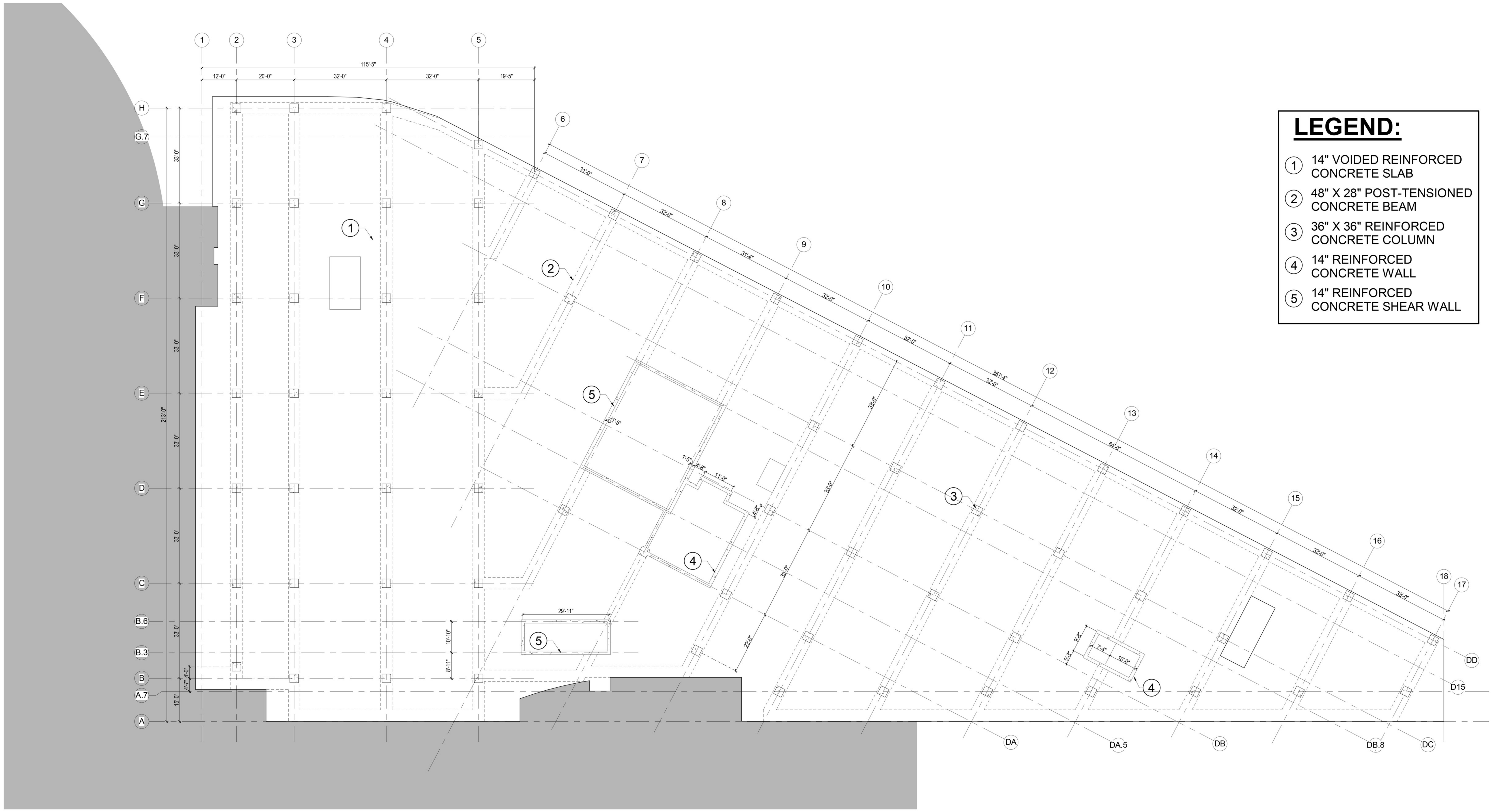
SCALE 1/16" = 1'-0"

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
FOUNDATION PLAN

S-101



LEGEND:

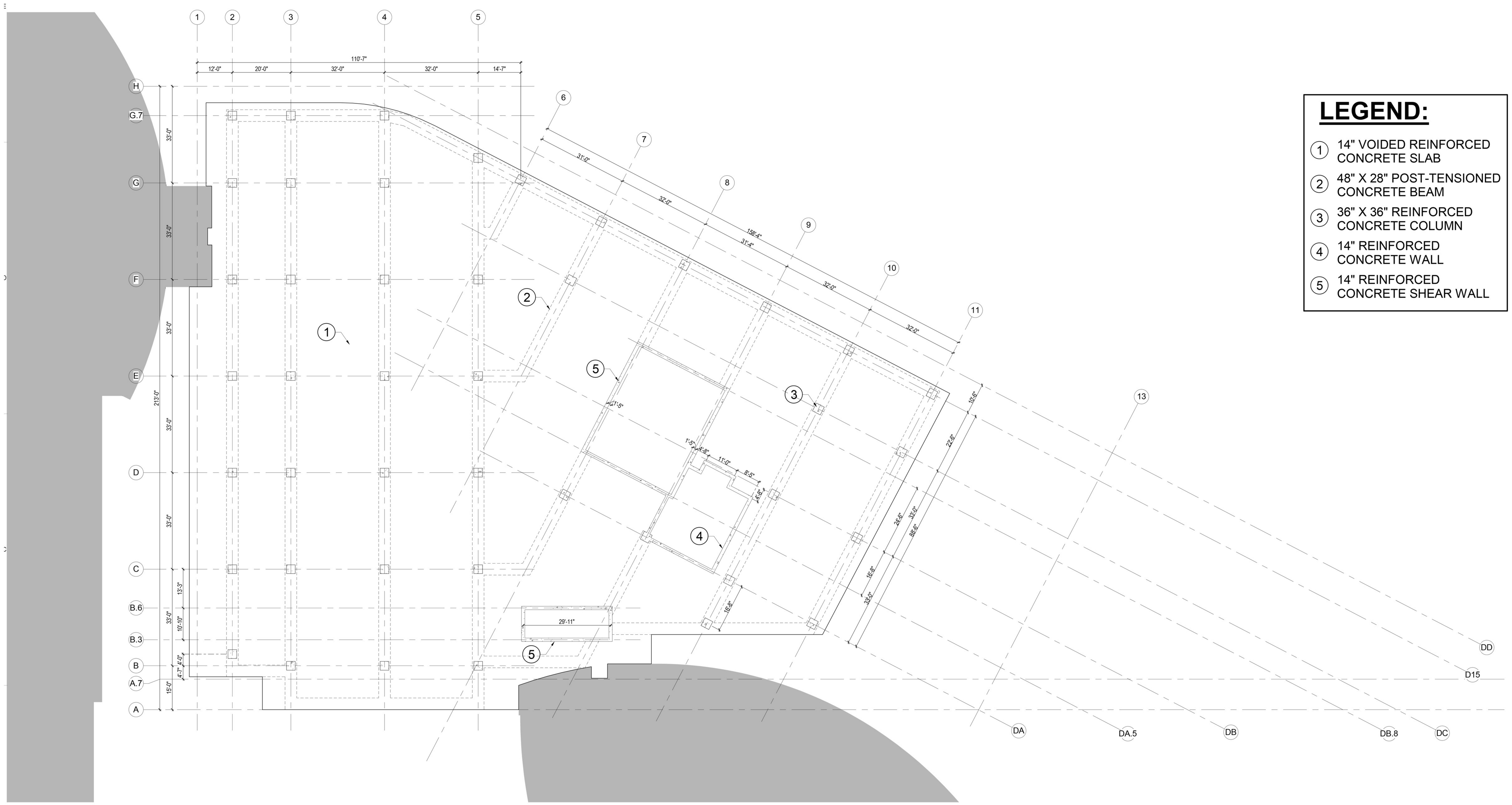
1. 14" VOIDED REINFORCED CONCRETE SLAB
2. 48" X 28" POST-TENSIONED CONCRETE BEAM
3. 36" X 36" REINFORCED CONCRETE COLUMN
4. 14" REINFORCED CONCRETE WALL
5. 14" REINFORCED CONCRETE SHEAR WALL

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
TYPICAL LOWER LEVEL
FRAMING PLAN

S-102



LEGEND:

1. 14" VOIDED REINFORCED CONCRETE SLAB
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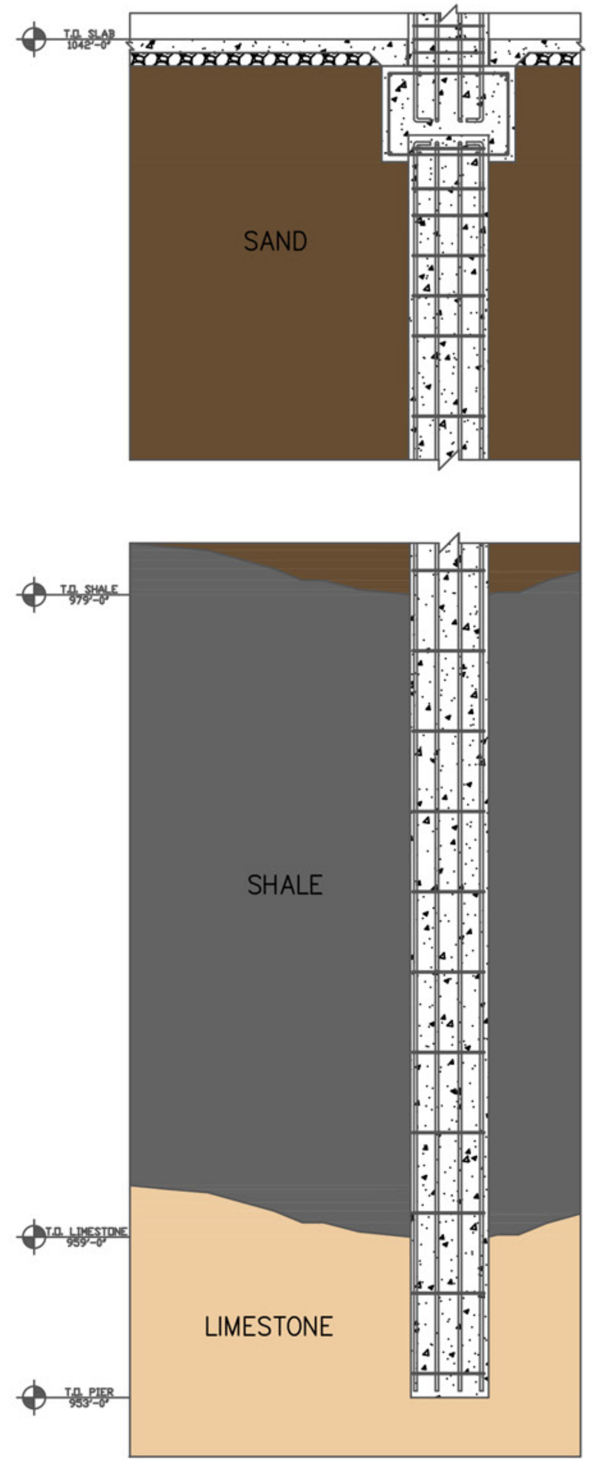
MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
TYPICAL TOWER LEVEL
FRAMING PLAN

S-103



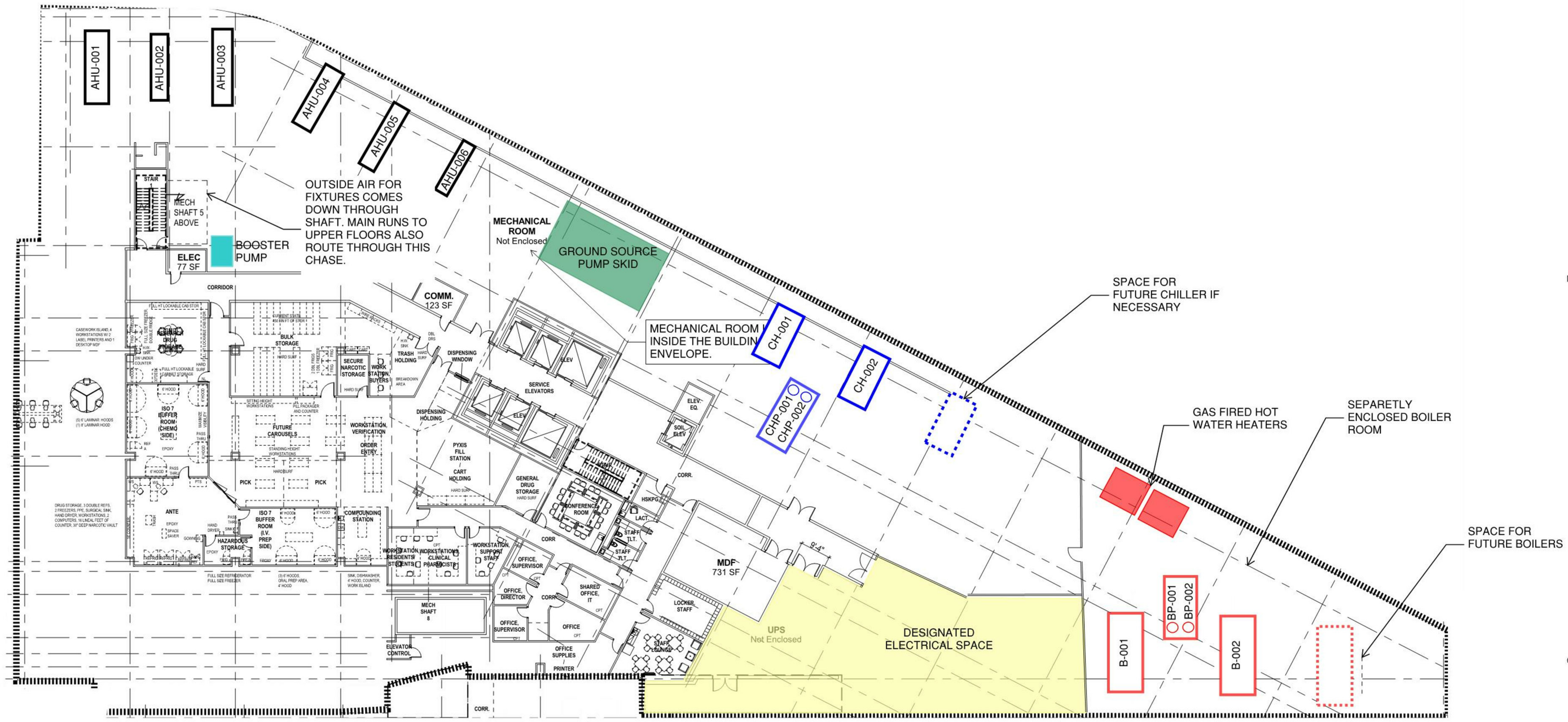
SOIL ELEVATION (A)
NO SCALE

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
SECTIONS

S-201



1/16" = 1'

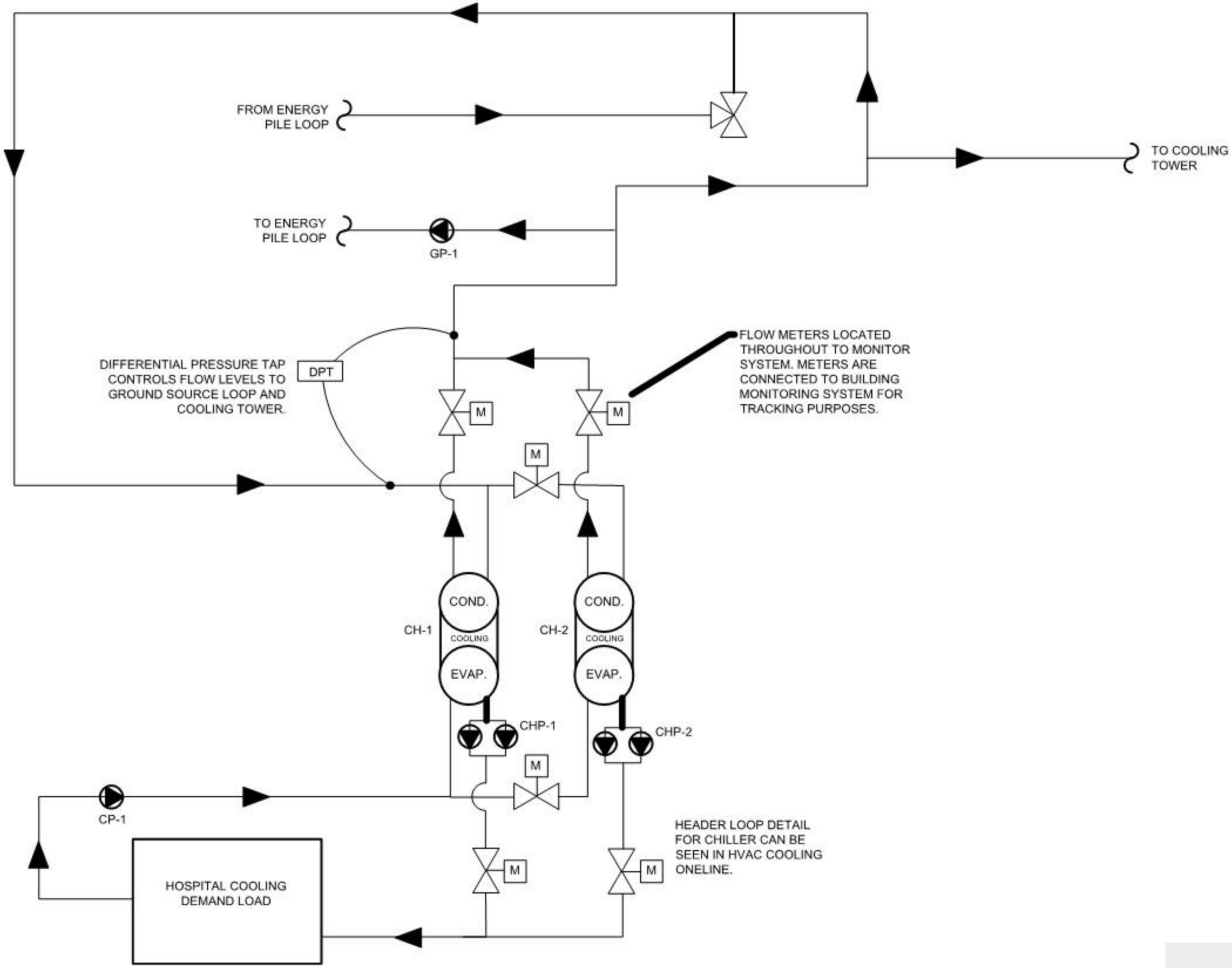
1 LOWER LEVEL 5 CENTRAL PLANT MECHANICAL ROOM
1/32" = 1'-0"

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
MECHANICAL ROOM LAYOUTS

M-103



1 ENERGY PILE HVAC ONE LINE
NTS

MUREX
EST 2017-18

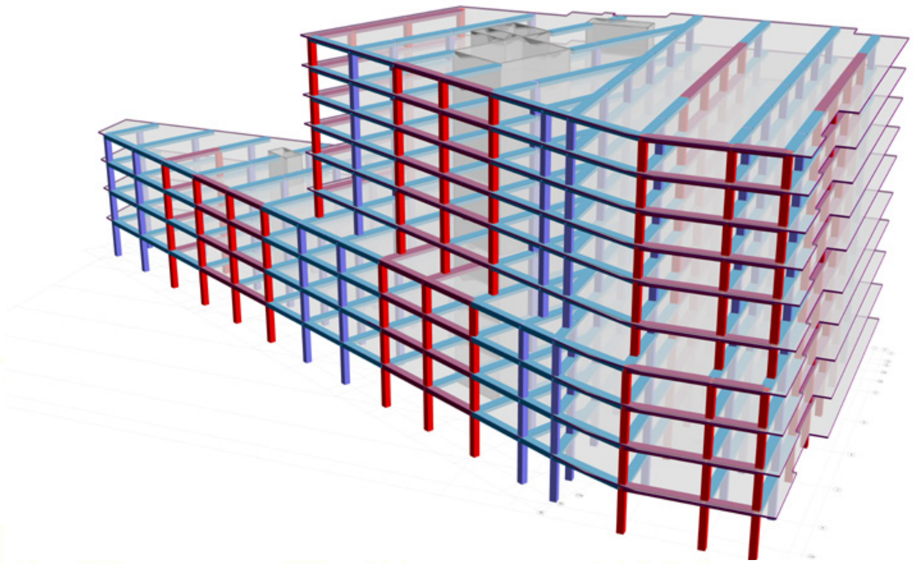
PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
GROUND LOOP
HVAC ONE LINES

M-109

2.1.0 Executive Summary

Murex's design goals for the addition to the Children's Hospital and Medical Center of Omaha are to maximize safety, integrity, and sustainability. The team wants to provide a facility that prioritizes the operation of the medical center and the young patients that call this hospital their temporary home. Additionally, Murex's cross disciplinary team has collaborated to fulfill the overall competition challenges. This project submittal contains the design details of the structural components and corresponding design philosophy. The following are highlights of Murex's structural design:



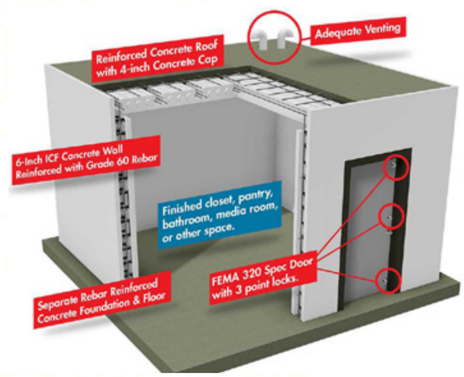
DRILLED PIER FOUNDATION SYSTEM

36 inch round drilled piers, which are supported by shale at a depth of 89 feet, is the primary foundation system for this building. Implementation of geothermal energy tubing within the piers allows for energy efficiency for the mechanical system within the foundation system.

VOIDED-SLAB FLOOR SYSTEM

A 14 inch concrete slab with 10 inch recycled plastic voids allows for a 31% reduction of concrete. The combination of the voided slab with post-tensioned beams allows for a lower overall building height. The typical bay spacing of 32 feet ensures a robust structure with high integrity and minimal architectural disruptions.

FEMA TORNADO SHELTER FACADE



This building will be equipped with a FEMA Tornado shelter in Lower Level 5 that is designed for 250 MPH wind speeds in an EF-5 tornado, as well as a safe room on each floor. These multiple refugee areas and tornado shelter allow occupant safety to be a main priority.

Integrated Project Delivery

Within each disciplinary team, Murex coordinated early in the design process to deliver the most efficient and constructable final design. This integrative design approach allowed Murex to achieve the overarching project challenges and offer the city of Omaha a higher performing building through innovative, value-added efforts.

2. STRUCTURAL NARRATIVE

2.1.0 Executive Summary
2.2.0 Project Introduction
2.3.0 Murex's Mission
2.4.0 Overall Competition Challenges
2.5.0 Design Criteria
2.5.1 Design Codes & Standards
2.5.2 Design & Analysis Procedure
2.6.0 Foundation
2.6.1 Drilled Piers
2.6.2 Design Rationale/Benefits
2.7.0 Gravity System Design
2.7.1 Voided Slab System
2.7.2 Post-Tensioned Beams
2.7.3 Column Design
2.7.4 Design Rationale/Benefits
2.7.5 Modeling Methodology
2.7.6 Gravity System Summary
2.8.0 Lateral Systems
2.8.1 Shear Walls & Moment Frames
2.8.2 Design Rationale/Benefits
2.9.0 Conclusion

2.2.0 Project Introduction

The Children's Hospital and Medical Center of Omaha is a proposed addition to the NICU and PICU as well as a new Cardiac Care Center and Fetal Care Program. This new ten story tower and four story ancillary podium project site is located adjacent to West Dodge Road, one of the busiest roads in the city. Throughout the structural design for the 2018 Competition Challenge, Murex wanted to deliver solutions to the overall project challenges, as well as align with individual team goals through an innovative facade system coupled with an integrated foundation and sustainable floor system. Murex has focused its design on maximizing safety, integrity, and sustainability to create a cohesive, efficient design.

2.3.0 Murex's Mission

The Children's Hospital and Medical Center of Omaha is an impactful part of the Omaha community with clear goals set up:

- Making a personal commitment to safety
- Acting with integrity
- Using resources wisely

Murex has aligned its design with this set of goals. These guiding principles ensure the continued positive impact on the growing Omaha community.

2.4.0 Overall Competition Challenges

The 2018 AEI Student Competition for the Children's Hospital and Medical Center of Omaha included 3 specific challenge areas:

- Enclosure
- Smart Building Integration
- Disaster Response Planning

The following subsections include how Murex addressed each of these challenges. Further details of each structural system can be found in their designated section of this narrative.

A. Enclosure

Murex wanted to select a high performance façade that integrated with all the building systems, as well proving to be aesthetically pleasing. Murex began a schematic design for its enclosure early in the design process to ensure the best selection. After discussions and iterations between the Murex architect, mechanical team, and structural team, the selection for the enclosure is a rear ventilated terracotta cladding. This enclosure will be provided by NBK Architectural Terracotta whom are known for their innovative engineered facade designs. After reviewing multiple options, the Terrart-Large exterior shell Terrart Rainscreen Support System was selected for its sustainability. In addition, Terrart-Custom design pieces were selected for the lower levels curved architecture.

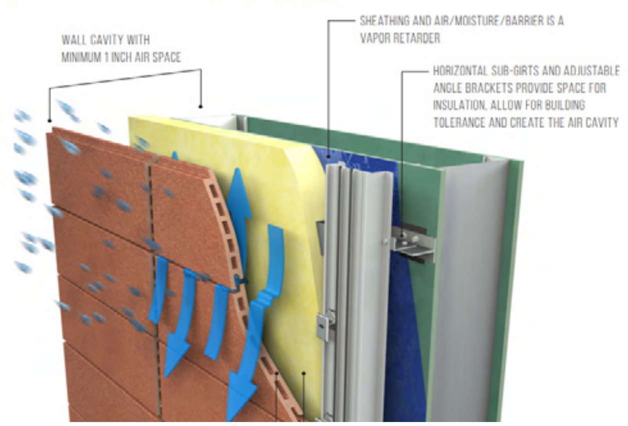


Figure: Rainscreen Support System

The structural team's safety and integrity goals were heavily involved within the selection of the Terrart-Large façade component. Since these large façade units are lightweight they have minimal impact to the structure, but integrate very well with the mechanical system as it has ventilation capability. Terrart has standard connection details to the structural system and can provide specific "NBK Clips" that make installment easy and efficient for the construction team. This facade will be connected to the cold-form steel exterior studs or the reinforced concrete columns and post-tensioned beams using the clips. NBK products are individually manufactured based on the project's specifications and are capable of withstanding high winds.

B. Smart Building Integration

As a team, Murex emphasized integration throughout the entire design process. Each design decision considered by any discipline was brought forward to the whole team to see if there was a more efficient, innovative and integrated method to implement it into the project.

A major example of the integration in this project is in the sustainable foundation system. The geothermal piping located within the drilled piers required coordination of the structural team with both the mechanical and construction teams. In order to prevent overall failure of a pier, such as a leak in one of the energy piles, Murex has decided to have each pile on a separate shut-off system in case a leak occurs. The separate shut-off systems allow the remainder of the system to operate.In addition, casing has been provided for the geothermal tubing for redundancy and prevention of structural damage to the foundation system. One of Murex's overall team goals is to maximize sustainability in the design, and this integrated foundation system incorporates that goal very well.

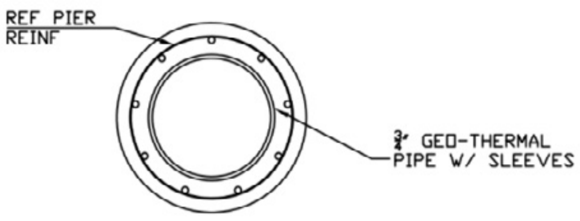


Figure: Typical Pier Detail

C. Disaster Response Planning

Murex has implemented several different aspects into the design so that in the instance of extreme events, the facility may continue to render medical services consistent with the day-to-day operations. This includes:

- Tornado Shelter located in the lowest level of the building
- Refugee Areas on each level for safety in the event of a tornado or an active shooter situation
- Tension Laps for the bottom steel in the columns to increase robustness if an explosion occurred and resulted in the loss of a column

The tornado shelter is located in Lower Level 5. Refugee areas with a hardened shell on each floor are provided. The specific locations of these areas can be seen on the plan below.

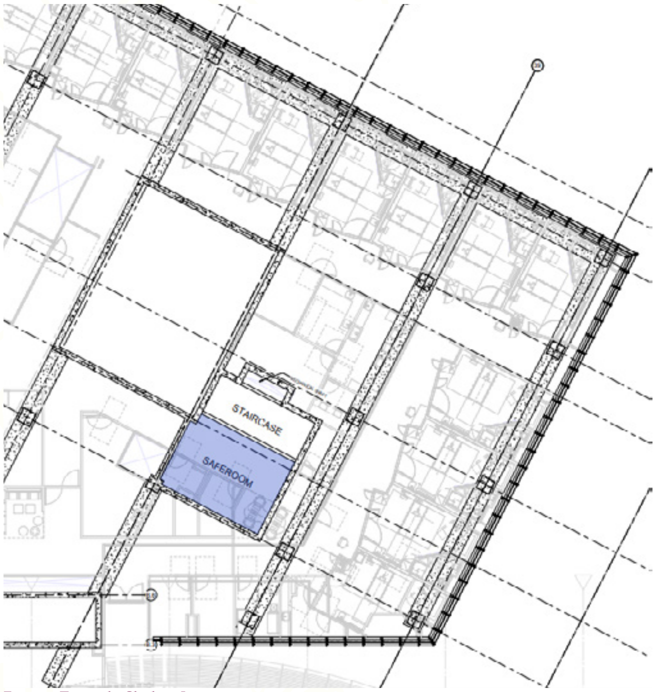


Figure: Tornado Shelter Location

TThe basement tornado shelter will be the primary safe area in the building in the event of a tornado, so everyone who can be relocated down there will be. There is approximately 10,000 square feet of comfortable space in Lower Level 5 that could be utilized as the safe space during a tornado. However, the entire Lower Level 5, which is mostly mechanical and electrical rooms, is over 50,000 square feet and this entire level will be designed as a FEMA shelter able to resist the loads of an EF-5 tornado. This is the largest shelter that could fit within the architecture plan where the most people would be able to take cover in this natural disaster. Early collaboration with the architect on the project was the best way to create these safe zones in the building. For this design, Murex provided a hardened shell room on each floor in addition to this basement tornado shelter. The hardened shell space could be allocated as a safe space during an active shooter situation in addition to providing additional safety during a tornado. The conditions of some patients may restrict their ability to be moved down to the basement as well as the warning timeline of such event, so these hardened shells on each floor are available for these patients.

Murex's design contains the option of providing a FEMA tornado shelter on each level. If the owner would like to make the additional investment then Murex design is very capable of changing all of the refugee areas into FEMA tornado shelters on each floor. The tornado safe rooms on each level encase approximately 400 square feet of usable space, a staircase, and a mechanical shaft in order to integrate the mechanical design for disaster preparedness. According to FEMA 453: Design Guidance for Shelters and Safe Rooms, a standing adult or child requires 5 square feet, a person in a wheelchair requires 10 square feet, and a bedridden patient requires 30 square feet. The safe room of 400 square feet on each level should provide enough space for the anticipated number of occupants for all of the people who are not able to get into the FEMA tornado shelter in the basement. The table below breaks down the number of anticipated people in each refugee room, where it is assumed that every wheelchair or bedridden patient will have a standing worker with them. This table shows that the 400 square foot space should be adequate for the assumed people on each floor.

Type	People	SF/Person	Total (sf)
Standing	15	5	75
Wheelchair	5	10	50
Bedridden	9	30	270
Total	29	45	395

2.5.0 Design Criteria

2.5.1 Design Codes & Standards

Omaha, Nebraska adopts the 2006 International Building Code as the primary building standard. However, the Murex structural team decided to bring the project standard up to the 2015 International Building Code. The 2015 IBC, which references the American Society of Civil Engineers 7-10, guided the Murex structural team in determining the loading criteria, combinations, and requirements. The City of Omaha Permits and Inspection Division provided some guidelines within the "Engineering Data" that assisted and set the foundation of the loading conditions. Murex also accounted for additional considerations due to the type of building. Since this building is a hospital, the Risk Category is IV which significantly increased load calculations and increased minimum requirements. Murex's use of the 2015 IBC instead of the 2006 IBC created a more conservative load calculation, which was utilized in the design of each structural member to create a safe and resilient structural system.

2.5.2 Design and Analysis Procedure

The structural system for this design is comprised of a voided-slab floor system and post-tensioned beams supported by a drilled pier foundation. The primary material used for Murex's structural system is reinforced concrete. The Murex structural team proceeded using a combination of both hand calculations and structural engineering softwares. Throughout the design process, the Murex team referred to its hand calculations in order to verify the adequacy of the computer program calculations, as well as optimize the various components of the building's structural elements. Thus, when conducting the assortment of hand calculations, guidelines such as The Concrete Reinforcing Steel Institute, American Concrete Institute and Pre-Stressed Concrete Institute were utilized. The main structural software used is the RAM Structural Package which includes Structural System, Concept, and Elements.

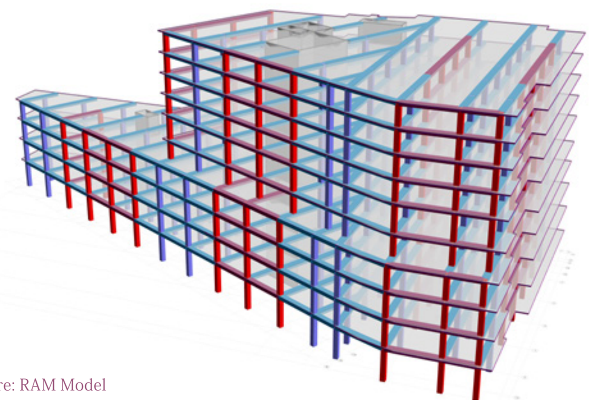


Figure: RAM Model

2.6.0 Foundation

The foundation system selection for this building is a drilled pier system integrated with geothermal piles. Secant piles hold back the foundation from the existing building as well as grade beams between piles and then the slab-on-grade.

The Murex team initially looked for innovative solutions to the design challenge. The team explored the following different options for foundation solutions:

SYSTEM	PROS	CONS
Webbed (Shallow)	- Proven capable of supporting high-rise structures - Popular in Europe and Middle East	- Goes against recommendation of Geotechnical Report
Auger Cast Piles (Deep)	- Recommended by the Geotechnical Report	- Driven - Cannot incorporate Geothermal Energy Piles
Drilled Piers (Deep)	- Smaller footprint - Allows for integration of Geothermal Piles - Recommended by the Geotechnical Report	- Stricter Supervision required for concrete pouring -Subsidence may occur if not properly supported

The given geotechnical report suggested a deep foundation based on the cohesive and granular nature of the soils on the site. After considering the pros and cons above as well as the recommendations from the geotechnical report, Murex chose to implement a Drilled Pier, or Drilled Shaft, foundation system. Compared to a shallow webbed foundation, a Drilled Pier foundation is proven more effective and efficient. With this foundation choice, the Murex team was able to incorporate a sustainable, integrated design by inserting a Geothermal Pile mechanical system within the piers. This additional integration was only possible with early coordination between the mechanical, structural and construction teams. Auger Cast Piles were another valid option suggested by the geotechnical report as a deep foundation option. However, not only are they driven which Murex wanted to avoid, but they also could not have the geothermal piles integrated into them.

2.6.1 Drilled Piers

Per recommendations and guidance of the geotechnical report and Concrete Reinforcing Steel Institute: Design Handbook, the piers will have a diameter of 36 inches and extend down 89 feet below the slab-on-grade. There will be grade beams that are 48 inches deep and 30 inches wide for basement wall support below the slab-on-grade, connecting the piers. It was required for the drilled piers to go a minimum of 26 feet into the bedrock, so at a depth of eighty-nine feet, this requirement is met. This depth of the foundation is common for depths found in Omaha. 36 inches is the smallest allowable diameter per the geotechnical report for the piers and the structural team calculated that this size is more than adequate for our design.

Each pier will be cased during construction and capable of carrying an ultimate load of about 3,100 kips. Within the drilled piers, Murex will be integrating a sustainable design of geothermal piles for mechanical use, which is further addressed in the Murex's mechanical team submission. The impacts structurally of these geothermal piles inside the foundation piers was initially a concern when deciding to implement them into the design. The concern was that inserting these energy piles would alter the structural integrity of the piers and would cause an increase in either the size, depth or number required. However, after further research and coordination between the disciplines, we found that this integrated and sustainable energy foundation could be spiraled through the piers and as long as they are at least 6 inches in from the edge of the piers, that the current sizing and spacing is still sufficient. Below is a visual of what a spiral geothermal pile would look like.

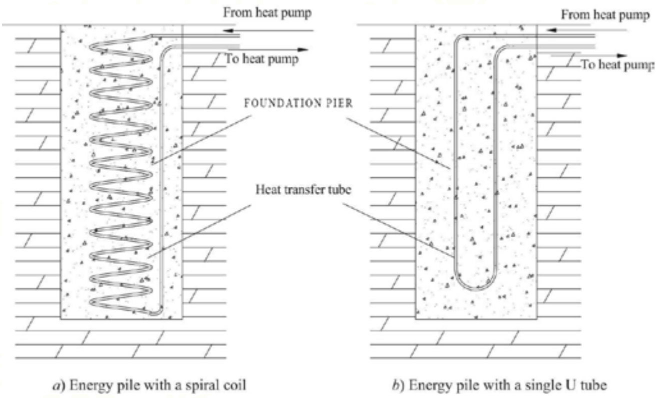


Figure: Spiral Coil within Drilled Pier

The elevators are supported by a mat slab foundation connected to drilled piers. The grade beams in this area are the same depth as in the rest of the foundation.

2.6.2 Design Rationale/Benefits

The many benefits in implementing this drilled pier system are summarized below.

Benefit	Rationale
Integration	Allows for mechanical piles to run through
Smaller Footprint	Minimize disruptions to existing structure
Drilled not Driven	Less equipment Less construction noise
Lateral Resistance	High Wind Resistance High Bearing Capacity

One of the main reasons for selecting this system is the smaller footprint it provides next to the existing hospital structure. With this, an important design consideration was determining how to excavate this foundation without disrupting the adjacent structure. Collaboration with the construction team was required to determine how to design the edges of the foundation next the existing hospital structure. This coordination resulted in the decision to support the edge columns with cantilevered grade beams. These will span back to the drilled piers along secant piles and tie backs, as seen on the framing plan. These cantilevered grade beams make this foundation more constructable as the space will be accessible for the drill rig to drill the holes.

Compared to pile driving, the equipment necessary for drilled piers is significantly lighter as well as there is no noise during construction and no ground heaving necessary. Murex understands that if this foundation is not properly supported, it can cause subsidence and damage to adjoining structures. However, the combination of the cantilevered grade beams and ensuring high quality supervision on site, Murex believes this will not be an issue for our project.

In designing the foundation as a fixed connection to the columns, this achieves a higher integrity and resistance to lateral loads, such as high winds that would occur during a tornado. The base of a drilled pier also provides great bearing capacity and resistance to uplift caused by similar wind load cases. Disaster response planning was one of the challenges for this project, so in order for this building to continue to render medical services after an extreme event, a foundation capable of resisting this is an important step.

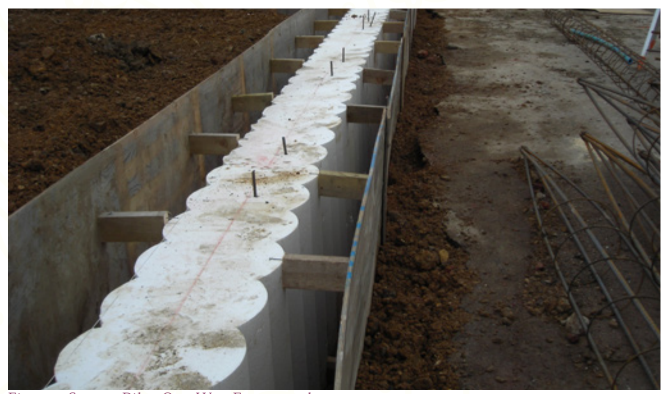


Figure: Secant Piles One Way Framework

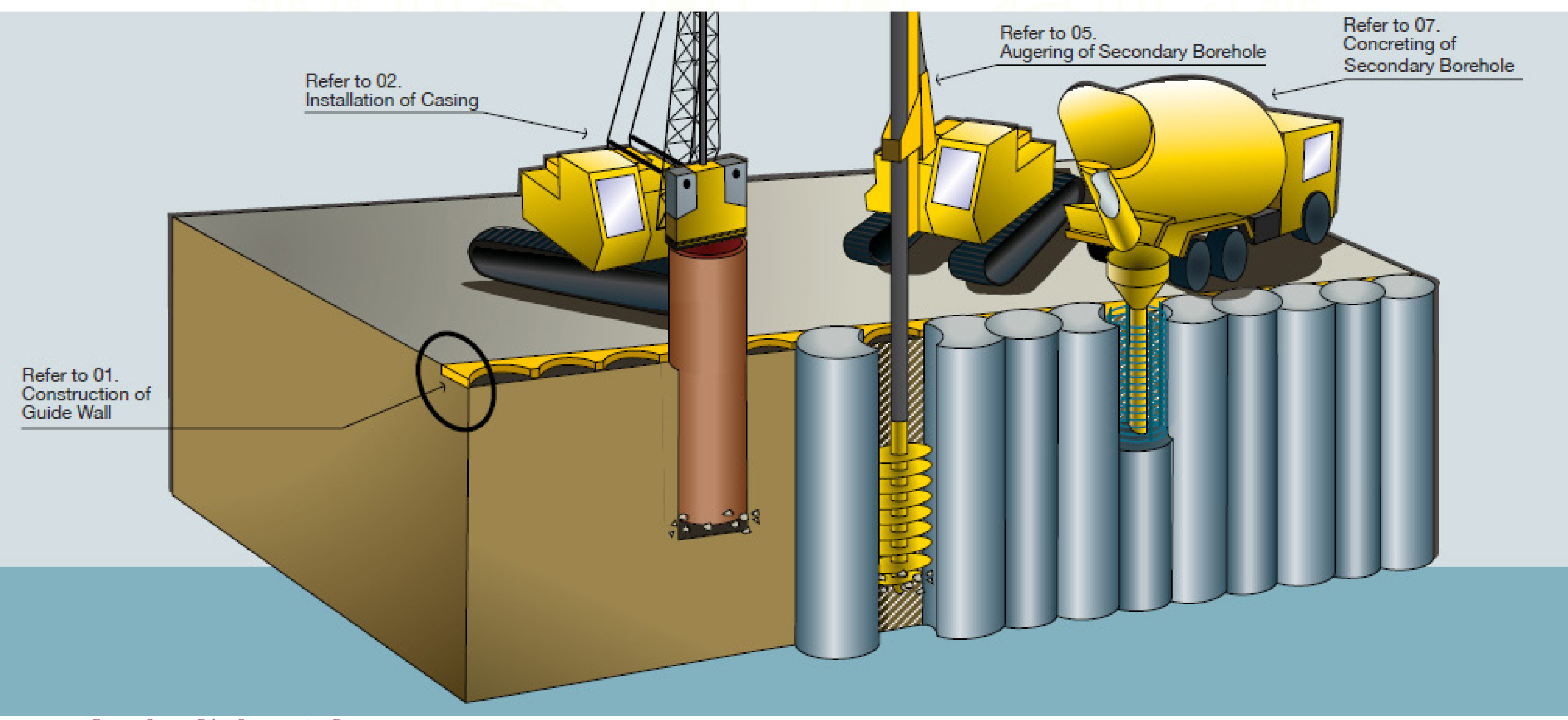


Figure: Secant Piles Construction Process

The construction of foundation walls adjacent to existing structures and busy roads creates a lot of challenges for the contractor. In order to solve this problem and ease construction, eighteen inch secant piles will be drilled around the perimeter of the structure. Secant piles will prevent the soil from collapsing during excavation and keep the integrity of the existing buildings during construction. The secant piles will minimize the lateral soil pressure on the foundation walls, which allowed the Murex structural design to decrease the thickness of the foundation walls from 18 inches down to 12 inches. Secant pile construction is much less noisy than traditional sheet pile construction and will reduce the disturbance of the patients during construction. Although the cost of drilling and one-way formwork for the walls will be costly, the increased safety and integrity of the secant piles will create a more resilient foundation system.

2.7.0 Gravity System Design

The following gravity systems and their effects were considered in this design:

SYSTEM	PROS	CONS
Composite Steel	- Lateral system incorporated easily	- Bad Vibration Control
Post-Tensioned Concrete Slab	- Big Bay Spacing - Reduction in Concrete	- Restricted future use - Drilling restrictions
Voided-Slab Concrete Slab	- Recycled Voids - Reduction in Concrete	- Not very common in America

The floor system selected for this design is a voided slab floor system with post-tensioned beams. This system will have a typical 32 foot span with a 14 inch slab. The voided slab system is more commonly found in Europe, but has been increasingly used in the United States. Most recently, the Kennedy Center of Performing Arts in D.C. is being constructed using this system as well as the University of Iowa Art Building.

This project presented the challenge of designing two different framing plans- one for the lower levels and one for the tower levels. Each of the lower levels were designed essentially the same way as were the tower levels, with the main difference being which parts of the slabs are voided versus not, based on activity in the spaces. With the goal of prioritizing safety, the structural team started placing columns and setting a framing plan to minimize disruptions for the architecture while still maintaining structural integrity. After considering span-to-depth requirements of the voided slab, several iterations were made to create the most efficient framing plan for this building based on the selected systems. A typical floor framing layout courtesy of the RAM Model can be seen below.

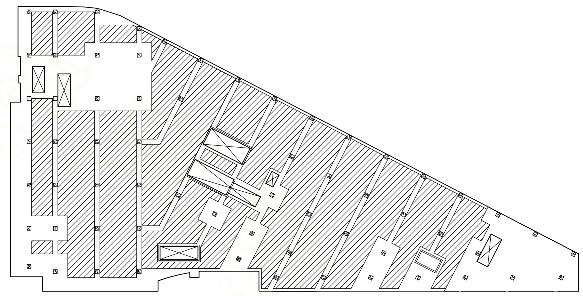
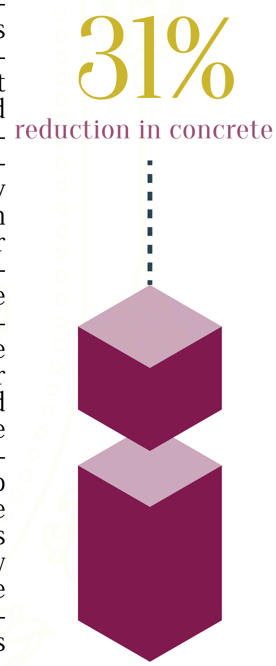


Figure: Voided Slab Locations

2.7.1 Voided Slab System



The decision to use a voided slab floor system was a result of the team's constant desire to implement a resilient idea that could deliver the highest quality building without exceeding the budget. Many ideas were considered in the decision process for the floor system such composite steel , pan or waffle formed slab, and post-tensioned slabs. Composite steel was the first floor system idea eliminated due to the low resistance to vibration that is present in steel compared to concrete. However, once the voided slab system was discovered, Murex knew that it was the best one for this project. The voided slab system reduces the overall volume of concrete used and weight of the slab by having recycled plastic voids instead of a solid flat plate slab.

For this project, the floor system is a 14 inch concrete slab with ten inch spherical voids. The implementation of the voids result in over a thirty percent reduction of concrete. The voids are implemented in every slab, except where noted. These exceptions include areas with heavy equipment, such as MRI machines or mechanical systems. Additionally, the slabs in the safe rooms will not be voided like the rest of the floor system in order to amplify the safety and integrity of the structure.

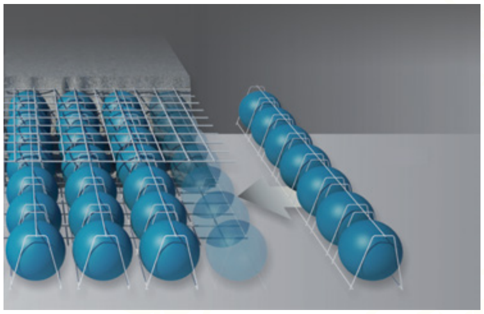


Figure: Cobiax ECO-Line

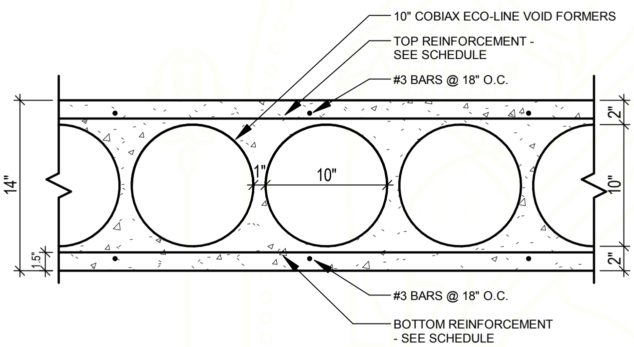


Figure: Voided Slab Cut Section

2.7.2 Post-Tensioned Beams

Post-tensioning the beams in the building offered an opportunity that, paired with the voided slab system, allows Murex to maximize bay spacing and minimize the number of interior columns required. The design calls for these beams to be 28 inches deep by 48 inches wide, with a concrete compressive strength of 5,000 psi. A section of which can be seen below:

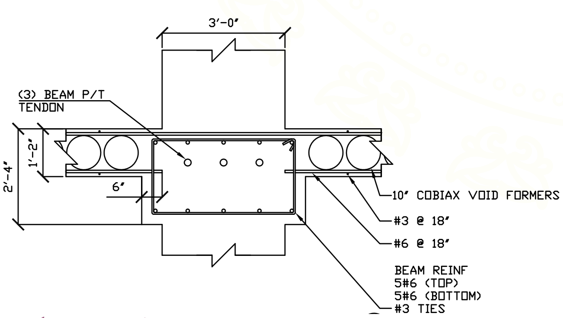


Figure: beam column connection

The choice to use the post-tensioning in the beams instead of in the slab ultimately came down to drilling restrictions that post-tensioning the slabs presented. Murex understands that drilling into a post-tensioned slab can be a major issue if any of the tendons are broken as the structural integrity of the entire slab can then be compromised. Given the nature of this building, having flexibility to adjust the use of rooms or future installments, Murex decided that the limitations post-tensioned slabs presented were too great, but still wanted to find a way to implement this type of design into the project. The use of post-tensioned concrete beams instead of traditionally reinforced beams allows for shallower members, which optimizes plenum space for the mechanical and electrical systems and shorter story heights. All of these factors will decrease the amount of materials used in the facade and of concrete, increasing the overall sustainability.

2.7.3 Column Design

The typical column design for this structural system is a 36 inch square concrete column with a compressive strength of 10,000 psi and reinforced with 10 #11 bars. The Murex structural team's primary super-structure material is reinforced concrete. The column design keeps with this design choice for uniformity, constructability and to further increase the design integrity. The idea to design with structural steel instead of reinforced concrete columns came up in the design process. After collaborating with the construction team, the decision to keep the columns in the primary material roots back to the availability in the area. Murex decided to design with the more sustainable choice, as concrete is locally sourced in the area and steel columns would need to be imported.

Once the governing gravity loads were determined (Load Calculations Pg 36), which took load combinations and the column layout into consideration, the columns were designed following the American Concrete Institute guidelines. The column design for just pure axial load called for 24 inch square reinforced concrete columns, but adding in bending and slenderness that come with a ten story structure, the size of the columns will increase. After a few iterations, Murex determined that 36 inch square columns were adequate. One of the major differences for the column design versus the rest of the building is that the Murex team chose to implement a significantly higher strength concrete due to the high axial loads interacting with the columns. The interaction diagram for this column design helped the structural team further understand and analyze their design choice. (Column Calculation/Interaction Diagram Pg 39).

2.7.4 Design Rationale/Benefits

Since this voided slab system is not as common in America as other systems, Murex wanted to confirm the product availability. There are two major producers of high density, recycled polyethylene (HDPE) voids in America: Washington based GRAEF's BubbleDeck and Massachusetts based Cobiax by Barker Steel. After reaching out to both, Murex found that Cobiax was an excellent solution for this project.

The voided slab system presents many advantages for the project, as can be seen in the table below:

- Use of Recycled Voids
- Reduction of Concrete
- Thinner Slabs with Bigger Bays

reduction of 21 trucks

Namely, due to the reduction in the amount of concrete being used and the recycled nature of the Cobiax voids, this floor system is incredibly sustainable. The implementation of this voided slab system has allowed Murex to reduce the amount of concrete required for a traditional system by over 200 cubic yards and over 25,000 pounds. The lower amount of concrete required means less carbon dioxide emission and less overall direct building materials, which enhances the sustainability of the building. As well as that, the reduced weight permits reduced columns, walls and foundations by as much as 40%. The recycled plastic voids are made of HDPE, which is the second most used type of plastic in the U.S. and is used for common household items like plastic bags and milk jugs. The recycled spherical voids also increase the sustainability of the design by reducing the amount of plastic in landfills by putting the plastic inside the slabs. The concrete mix design includes replacing 30% of the Portland cement with fly ash and slag in order to reduce toxic emissions during cement production while still maintaining structural integrity. These voids are omitted near columns to maintain slab punching-shear capacity as well as under heavy equipment to minimize vibrations.

Vibration control was something that Murex wanted to ensure would not be an issue in this space due to the critical operating procedures that occur in the children's hospital. A voided concrete slab system designed in accordance with the minimum serviceability criteria as set in the Design Guide for Vibrations of Reinforced Concrete Floor Systems (CRSI 2014b) have been found to readily satisfy vibration criteria. Murex designed above these minimum requirements so vibration will not be an issue in these critical locations. Vibration control is typically more of a problem in steel structures, which is yet another reason Murex designed with mainly concrete.

Early coordination with the construction team allowed Murex to create the most efficient schedule for installation of this voided slab system. The recent introduction to the U.S. of this system is gathering significant interest due to its reduced construction costs such as that on average, one semi-truck load of voids replaces six ready-mix truckloads of concrete. Specifically for this project, due to the amount of concrete that Murex is saving, the number of concrete trucks required is reduced by over 20 trucks. This has even caused contractors and engineers to convert projects to voided slab that were originally designed as structural steel systems.

A primary difference between a pan or waffle formed slab system and the void system is that when installed, the voids are lightweight and permanently encased in the concrete while pan and waffle forms must be removed and cleaned for reuse. The formwork for the voided slabs is also very simple and would allow for faster construction. Therefore, the construction of the voided slabs is complete after the concrete is poured.

2.7.5 Modeling Methodology

To help in the design of the hospital's gravity system, Murex utilized Bentley Engineering's RAM Structural Software package. First, a central model was created on Autodesk's Revit Software with all the dimensions which can be seen below. Then, Murex was able to import that model in RAM and size our members.

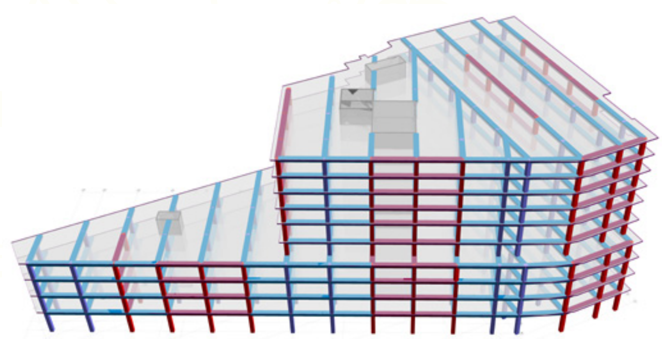


Figure: RAM MODEL

It should be noted that due to the fact that the voided slab system is not very common in USA yet, RAM did not offer a voided system design option on their software. So, the slab was designed by hand to determine what size would be needed off of the loads given. This was then inputted into the software with the "equivalent depth" for a solid concrete slab into the software. Murex calculated that "equivalent depth" of the fourteen inch voided slab to be just above nine inches of solid concrete, calculation can be seen in voided slab design document.

2.7.6 Gravity System Summary

Through coordination and collaboration with the entire design team, the structural team was able to design a gravity system that exceeded the goals for the project. The final design presents a cutting edge, efficient and constructable design that best meets the project challenges.

2.8.0 Lateral Systems

While seismic is generally not a controlling force iWhile seismic is generally not a controlling force in this region, both wind and seismic loads were calculated to determine their overall impact on the lateral system design. As predicted, wind is the governing lateral load for this project.

For a building of this size, it is typical to include an expansion joint. An ideal location for an expansion joint in this project would be at the connection between the lower level and the tower level. However, in reality, the spans on either side of this location are not suitable for an expansion joint to actually be inserted at that location. With that said, Murex has decided not to include an expansion joint in the design of the addition to the hospital, but has considered all the results of this. There will still be a 2" expansion joint between the existing structure and the new structure.

Concrete shear walls and moment frames were selected as the most efficient lateral system due to ease of construction and integration with the architecture. The concrete walls enclosing the elevator shafts are being utilized as shear walls.

2.8.1 Shear Walls and Moment Frames

The location of the shear walls and moment frames can be seen in plan below. For this lateral design, these two systems work together to resist the loads presented.

Every structure must incorporate vertical elements to transfer lateral loads, including wind, seismic, and stability force, through floor or roof diaphragms to the building foundation. Murex understands that lateral systems run from horizontal diaphragm to horizontal diaphragm. Shear walls typically resist lateral forces as a vertical diaphragm through in-plane shear. Moment frames resist lateral loads through flexural strength of members and continuity of columns and beams using rigid connections. These loads are transferred from beams to columns at rigid connection points. Since force is attracted to walls based on rigidity, the location of shear walls and moment frames in the plan is crucial in the success of the lateral system. A detail of a typical shear wall for this building can be seen below.

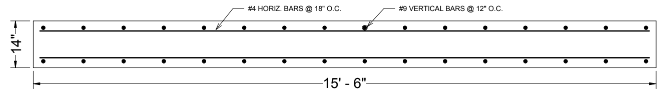


Figure: Typical Shear Wall Details

For a lateral system, if there is nothing to run to, such as an exterior moment frame, then the system needs to be cantilevered. Murex wanted to avoid cantilevering the lateral system as that can result in an increase of member sizes and costs. In the framing plan, it can be seen that most of the moment frames are located along the exterior bays of the structural system. On the east end of the lower level podium, the moment frame is not located on the exterior due to the shorter length of that bay. In result of this, the lateral resisting force will be cantilevered in this location, but the Murex structural team minimized this cantilever as much as possible.

2.8.2 Design Rationale/Benefits

Due to the location of the project being in a low seismic region and in an area where the probability of a tornado hitting is not very high, the lateral force resisting system was not as high of a concern as the gravity force system. The combination of concrete moment frames and shear walls in Murex's lateral design is a very resilient system and will maintain the structural integrity of the Children's Hospital and Medical Center in Omaha.

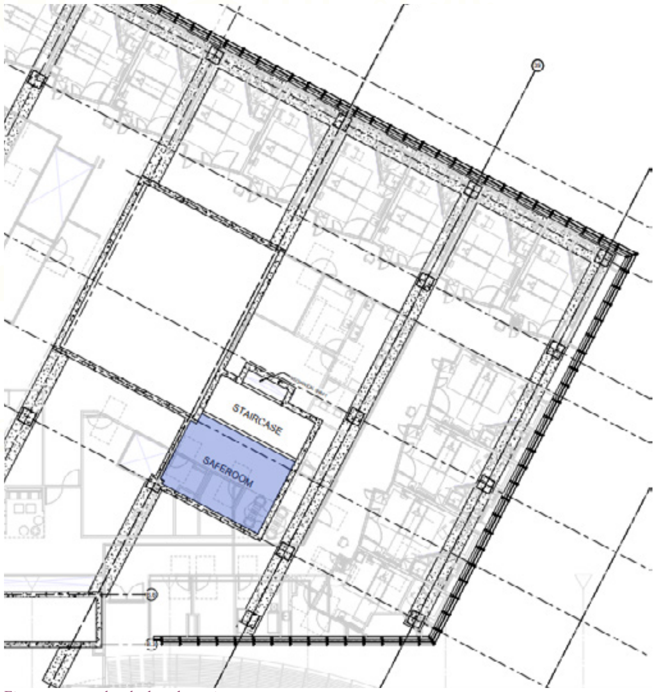


Figure: tornado shelter location

In designing the lateral system of this building, the structural team decided not to have the walls of the hardened shell rooms to be shear walls. This decision ultimately comes back to one of Murex's overall goals of safety. Although it would have been an easier design structurally if these walls were shear walls, it would not be as safe for the patients and occupants of the building during a natural disaster. Since force is attracted to walls based on rigidity, making the hardened shell walls shear walls would have drawn in a significant amount of additional force during a tornado, which is the last thing that the safest room on that floor is supposed to do.

The slabs in the safe rooms will not be voided like the rest of the floor system in order to amplify the safety and integrity of the structure. There are concrete walls encasing the tornado safe rooms on each level, but Murex chose to not make these shear walls. This decision was based on making the safe rooms even safer because if they were shear walls, the lateral forces from a tornado would be directed to these walls and could jeopardize the integrity of the structure in the event of a natural disaster.

2.9.0 Conclusion

Murex's structural design team worked to create an integrative and innovative design for the addition to the Children's Hospital and Medical Center in Omaha, Nebraska. Through collaboration amongst the other disciplines, Murex's structural team was able to produce an innovative structural system that met the overall challenge goals as well as individual team goals. With every aspect of the structural design of this project, Murex designed to prioritize safety and integrity as well as maximize sustainability.

DEAD / LIVE LOAD

Step Description	Calculations		Reference
	Code: ASCE 7-10		
Dead Loads	Per Chaper 3: Minimum Design Dead Loads		
	Typical Floor Dead Load:	20 psf	Table C3-1
	Miscellaneous MEP:	10 psf	
	Façade:		
	"Terrart Large"	12 psf	
	Normal Weight Concrete:	150 pcf	
Live Loads	Per Chapter 4: Minimum Uniformly Distributed Live Loads (L_o)		
	Floor Live Loads:		Table 4-1
	Operating Rooms/Labs:	60 psf	
	Patient Rooms:	40 psf	
	Lobbies/Corridors:	100 psf	
	Corridors Above 1st Floor:	80 psf	
	Mechanical/Electrical Room(s):	125 psf	
	Restrooms:	60 psf	
	Kitchen(s):	150 psf	
	Helipad:	60 psf	
	Roof Top Garden:	100 psf	
Live Load Reduction	Per Section 4.7.2: Reducation in Uniform Live Loads		
	Members for which a value of $K_{LL}A_T$ is 400 ft2 or more.		
	$L = L_o\left(0.25 + \frac{15}{\sqrt{K_{LL} \times A_T}}\right)$		Eq. 4.7-1
	Slab Design Example:		
	$L = L_o\left(0.25 + \frac{15}{\sqrt{K_{LL} \times A_T}}\right)$		
	L_o =	70 psf	Table 4-1
	K_{LL} =	1	Table 4-2
	A_T =	1024 ft^2	
	$L = 70\,psf\left(0.25 + \frac{15}{\sqrt{(1 \times 1024\,ft^2)}}\right)$		
	L =	50.3 psf	

SESIMIC LOAD

STEP DESCRIPTION	COMPUTATION				REFERENCE
General Parameters	*Code:*		***ASCE 7-10***		
	Risk Category:		IV		Table 1.5-1
	Importance Factor (I_e):		1.5		Table 1.5-2
	Site Class:		D		
Design Coefficients and Factors	S_S =	0.081 g	S_1 =	0.030 g	
	F_a =	1.6	F_v =	2.4	Table 11.4-1 & 2
	S_{ms} =	0.130 g	S_{m1} =	0.072 g	Eq. 11.4-1 & 2
	S_{ds} =	0.086 g	S_{d1} =	0.048 g	Eq. 11.4-3 & 4
	→ ***Sesimic Design Category A***				Table 11.6-1
Base Shear	F = 0.01 W =		**681 kips**		Eq. 1.4-1
	Dead Load of Building (W):		68,126 kips		
	The seismic base shear is less than the wind base shear. Therefore, wind is the governing lateral force.				

SNOW LOAD CALCULATION

Step Description	Calculations		Reference
	Code: ASCE 7-10: Chapter 7		
Building Information	Location: Omaha, NE		
	Risk Category:	IV	Table 1.5-1
	Type of Roof:	Flat	
	Ground Snow Load (p_g):	25 psf	Figure 7-1
	Exposure Factor (C_e):	0.9	Table 7-2
	Roof Exposure:	Fully Exposed	
	Terrain Category:	B	Section 26.7
	Thermal Factor (C_t):	1.0	Table 7-3
	Unheated and Open Air Structure		
	Snow Importance Factor:	1.20	Table 1.5-2
Balanced	Flat Roof Snow Loads (p_f):		Eq. 7.3-1
	$p_f = 0.7\,C_e C_t I_s p_g$		
	$p_f = (0.7)(0.9)(1.0)(1.20)(25\,psf)$		
	$p_f =$ 18.9 psf		
	Minimum Snow Load (p_m):		
	$p_m = 20\,psf\,I_s$ (Where p_g exceeds 20 psf)		Section 7.3.4
	$p_m = 20\,psf\,(1.20)$		
	$p_m =$ 24 psf		
	Rain-On-Snow Surcharge: +0 psf		Section 7.10
	For locations where pg is 20 psf or less, but not zero shall include a 5 psf rain-on-snow surcharge load.		

Step Description	Calculations		Reference
Unbalanced	**Wind Direction: North**		Section 7.7.1
	Leeward Drift on L2 from L8		
	Upwind Fetch (l_u):	200 ft	Figure 7-9
	Projection Height (h):	88 ft	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 4.616 ft		
	Clear Height (h_c):		
	$h_c =$ 86.61 ft		
	Drift Width (w):		
	$w =$ 18.47 ft		
	Surcharge Load (p_d):		
	$p_d =$ 79.63 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	103.6 psf	
Unbalanced	**Wind Direction: North**		Section 7.7.1
	Windward Drift on L2		
	Upwind Fetch (l_u):	237 ft	Figure 7-9
	Projection Height (h):	4 ft	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 4.972 ft (Note: Truncate h_d to h_c)		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 10.43 ft		
	Surcharge Load (p_d):		
	$p_d =$ 45 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	69 psf	

Step Description	Calculations		Reference
	Wind Direction: South		Section 7.7.1
	Leeward Drift on L2 Parapet		
	Upwind Fetch (l_u):	20 ft	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 1.339 ft		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 5.36 ft		
	Surcharge Load (p_d):		
	$p_d =$ 23.1 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	47.1 psf	
Unbalanced	**Wind Direction: South**		Section 7.7.1
	Windward Drift on L2 Wall		
	Upwind Fetch (l_u):	237 ft	Figure 7-9
	Projection Height (h):	88 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 4.972 ft		
	Clear Height (h_c):		
	$h_c =$ 86.61 ft		
	Drift Width (w):		
	$w =$ 19.89 ft		
	Surcharge Load (p_d):		
	$p_d =$ 85.77 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	109.8 psf	
	Wind Direction: East/West		Section 7.7.1
	Windward Drift on Parapet with Worst Case		
	Upwind Fetch (l_u):	140 ft	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 3.931 ft (Note: Truncate)		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 10.43 ft		
	Surcharge Load (p_d):		
	$p_d =$ 45 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	69 psf	
Unbalanced	**Wind Direction: East/West**		Section 7.7.1
	Leeward Drift on Parapet		
	Upwind Fetch (l_u):	20 ft	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 1.339 ft		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 5.36 ft		
	Surcharge Load (p_d):		
	$p_d =$ 23.1 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	47.1 psf	

Step Description	Calculations		Reference
	Wind Direction: North/South		Section 7.7.1
	Windward Drift on L8 Parapet with Worst Case		
	Upwind Fetch (l_u):	200 ft	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 4.616 ft (Note: Truncate)		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 10.43 ft		
	Surcharge Load (p_d):		
	$p_d =$ 45 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	69 psf	
Unbalanced	**Wind Direction: North/South**		Section 7.7.1
	Leeward Drift on L8 Parapet with Worst Case		
	Upwind Fetch (l_u):	20 ft (Note: Minimum)	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 1.339 ft		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 5.36 ft		
	Surcharge Load (p_d):		
	$p_d =$ 23.1 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	47.1 psf	
	Wind Direction: East/West		Section 7.7.1
	Windward Drift on L8 with Worst Case		
	Upwind Fetch (l_u):	216 ft	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 4.775 ft (Note: Truncate)		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 10.43 ft		
	Surcharge Load (p_d):		
	$p_d =$ 45 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	69 psf	
Unbalanced	**Wind Direction: East/West**		Section 7.7.1
	Leeward Drift on L8 Parapet		
	Upwind Fetch (l_u):	20 ft (Note: Minimum)	Figure 7-9
	Projection Height (h):	4 ft (Note: Upwind Fetch Minimum)	
	Snow Desity (γ):		
	$\gamma = 0.13p_g + 14 \geq 30\,pcf$		Eq. 7.7-1
	$\gamma =$ 17.25 pcf		
	Balanced Snow Height (h_b):		
	$h_b =$ 1.391 ft		
	Drift Height (h_d):		
	$h_d = 0.43\sqrt[3]{l_u}\sqrt[4]{p_g+10} - 1.5$		Figure 7-9
	$h_d =$ 1.339 ft		
	Clear Height (h_c):		
	$h_c =$ 2.609 ft		
	Drift Width (w):		
	$w =$ 5.36 ft		
	Surcharge Load (p_d):		
	$p_d =$ 23.1 psf		
	Balanced Snow Load (p_f):		
	$p_f =$ 24 psf		
	Peak Snow Load:	47.1 psf	

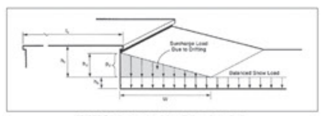


FIGURE 7.8 Configuration of Snow Drifts on Lower Roofs.

WIND LOAD CALCULATION

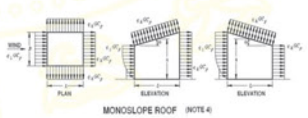
STEP DESCRIPTION	COMPUTATION			REFERENCE
General Parameters	*Code:*	*ASCE 7-10*		
	Risk Category:	IV		Table 1.5-1
	Importance Factor (I_w):	1.0		Table 1.5-2
	Exposure Category:	B		26.7.3
	Enclosure Classification:	Enclosed		
	Internal Pressure Coeff (GC_{pi}):	±0.18		Table 26.11-1
Building Geometry	Upper Roof Angle:	0°		
	Lower Roof Angle:	0°		
	Building Length:	480.0 ft.		
	Building Width (East):	30.0 ft.		
	Building Width (West):	208 ft.		
	Lower Roof Height:	51.0 ft.		
	Upper Roof Height:	143 ft.		
	Helipad Height:	153 ft.		
	Parapet Height:	4.0 ft.		
Velocity Pressure	Ultimate Wind Speed (V):	120 MPH		Fig. 26.5-1a
	Gust Effect Factor (G):	0.85		26.9.1
	Directionality Factor (K_d):	0.85		Table 26.6-1
	Topographic Factor (K_{zt}):	1.00		Fig. 26.8-1
	Velocity Pressure Exposure Coeff. (K_h):			Table 27.3-1
	Case 1: 15 ft.	0.570		
	Case 2: 18 ft.	0.600		
	Case 3: 35 ft.	0.730		
	Case 4: 51 ft.	0.814		
	Case 5: 55 ft.	0.830		
	Case 6: 65 ft.	0.870		
	Case 7: 83 ft.	0.939		
	Case 8: 97 ft.	0.981		
	Case 9: 111 ft.	1.018		
	Case 10: 125 ft.	1.053		
	Case 11: 143 ft.	1.096		
	Case 12: 147 ft.	1.104		
	Case 13: 153 ft.	1.116		
	Velocity Pressure (q_h):			Eq. 27.3-1
	Case 1: 15 ft.	17.86 PSF		
	Case 2: 18 ft.	18.80 PSF		
	Case 3: 35 ft.	22.87 PSF		
	Case 4: 51 ft.	25.51 PSF		
	Case 5: 55 ft.	26.01 PSF		
	Case 6: 65 ft.	27.26 PSF		
	Case 7: 83 ft.	29.42 PSF		
	Case 8: 97 ft.	30.74 PSF		
	Case 9: 111 ft.	31.88 PSF		
	Case 10: 125 ft.	32.98 PSF		
	Case 11: 143 ft.	34.34 PSF		
	Case 12: 147 ft.	34.59 PSF		
	Case 13: 153 ft.	34.97 PSF		

MWFRS

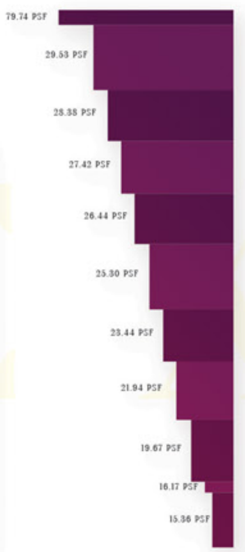
STEP DESCRIPTION	COMPUTATION			REFERENCE
Wall Pressure Coefficients (C_p)	Windward Wall:	0.8		Figure 7.4-1
	Leeward Wall:			
	Transverse (B > L):	-0.5		
	Longitudinal (L > B):	-0.44		
	Side Wall:	-0.7		
	Flat Roof:			
	0 to h:	-0.9	-0.18	
	h to 2h:	-0.5	-0.18	
	> 2h:	-0.3	-0.18	
	Parapet:			
	Windward:	1.5		
	Leeward:	-1.0		

STEP DESCRIPTION	COMPUTATION		REFERENCE
Transverse Design Wind Pressures (p):	Windward Wall (+):		Eq. 27.4-1
	Case 1: 15 ft.	8.93 PSF	
	Case 2: 18 ft.	9.40 PSF	
	Case 3: 35 ft.	11.44 PSF	
	Case 4: 51 ft.	12.75 PSF	
	Case 5: 55 ft.	13.00 PSF	
	Case 6: 65 ft.	13.63 PSF	
	Case 7: 83 ft.	14.71 PSF	
	Case 8: 97 ft.	15.37 PSF	
	Case 9: 111 ft.	15.94 PSF	
	Case 10: 125 ft.	16.49 PSF	
	Case 11: 143 ft.	17.17 PSF	
	Case 12: 147 ft.	17.30 PSF	
	Case 13: 153 ft.	17.48 PSF	
	Windward Wall (-):		
	Case 1: 15 ft.	15.36 PSF	
	Case 2: 18 ft.	16.17 PSF	
	Case 3: 35 ft.	19.67 PSF	
	Case 4: 51 ft.	21.94 PSF	
	Case 5: 55 ft.	22.37 PSF	
	Case 6: 65 ft.	23.44 PSF	
	Case 7: 83 ft.	25.30 PSF	
	Case 8: 97 ft.	26.44 PSF	
	Case 9: 111 ft.	27.42 PSF	
	Case 10: 125 ft.	28.36 PSF	
	Case 11: 143 ft.	29.53 PSF	
	Case 12: 147 ft.	29.75 PSF	
	Case 13: 153 ft.	30.07 PSF	
	Leeward Wall (+):	-20.78 PSF	
	Leeward Wall (-):	-8.41 PSF	
	Side Wall (+):	-26.62 PSF	
	Side Wall (-):	-14.25 PSF	
	Lower Roof (+):		
	0 to h:	-24.10 PSF	
	h to 2h:	-15.43 PSF	
	> 2h:	-11.10 PSF	
	Lower Roof (-):		
	0 to h:	-14.92 PSF	
	h to 2h:	-6.25 PSF	
	> 2h:	-1.91 PSF	
	Upper Roof (+):		
	0 to h:	-32.45 PSF	
	h to 2h:	-20.78 PSF	
	> 2h:	-14.94 PSF	
	Upper Roof (-):		
	0 to h:	-20.09 PSF	
	h to 2h:	-8.41 PSF	
	> 2h:	-2.58 PSF	
	Parapet:		
	Lower Roof:	59.95 PSF	
	Upper Roof:	79.74 PSF	
	Helipad:	80.60 PSF	
Longitudinal Design Wind Pressures (p):	Windward Wall (+):		Eq. 27.4-1
	Case 1: 15 ft.	8.93 PSF	
	Case 2: 18 ft.	9.40 PSF	
	Case 3: 35 ft.	11.44 PSF	
	Case 4: 51 ft.	12.75 PSF	
	Case 5: 55 ft.	13.00 PSF	
	Case 6: 65 ft.	13.63 PSF	
	Case 7: 83 ft.	14.71 PSF	
	Case 8: 97 ft.	15.37 PSF	
	Case 9: 111 ft.	15.94 PSF	
	Case 10: 125 ft.	16.49 PSF	
	Case 11: 143 ft.	17.17 PSF	
	Case 12: 147 ft.	17.30 PSF	
	Case 13: 153 ft.	17.48 PSF	
	Windward Wall (-):		
	Case 1: 15 ft.	15.36 PSF	
	Case 2: 18 ft.	16.17 PSF	
	Case 3: 35 ft.	19.67 PSF	
	Case 4: 51 ft.	21.94 PSF	
	Case 5: 55 ft.	22.37 PSF	
	Case 6: 65 ft.	23.44 PSF	
	Case 7: 83 ft.	25.30 PSF	
	Case 8: 97 ft.	26.44 PSF	
	Case 9: 111 ft.	27.42 PSF	
	Case 10: 125 ft.	28.36 PSF	
	Case 11: 143 ft.	29.53 PSF	
	Case 12: 147 ft.	29.75 PSF	
	Case 13: 153 ft.	30.07 PSF	
	Leeward Wall (+):	-19.03 PSF	
	Leeward Wall (-):	-6.66 PSF	
	Side Wall (+):	-26.62 PSF	
	Side Wall (-):	-14.25 PSF	
	Lower Roof (+):		
	0 to h:	-24.10 PSF	
	h to 2h:	-15.43 PSF	
	> 2h:	-11.10 PSF	
	Lower Roof (-):		
	0 to h:	-14.92 PSF	
	h to 2h:	-6.25 PSF	
	> 2h:	-1.91 PSF	
	Upper Roof (+):		
	0 to h:	-32.45 PSF	
	h to 2h:	-20.78 PSF	
	> 2h:	-14.94 PSF	
	Upper Roof (-):		
	0 to h:	-20.09 PSF	
	h to 2h:	-8.41 PSF	
	> 2h:	-2.58 PSF	
	Parapet:		
	Lower Roof:	59.95 PSF	
	Upper Roof:	79.74 PSF	
	Helipad:	80.60 PSF	

Base Shear	Transverse Base Shear:	**1632 kips**	*(GOVERNS)*
	Longitudinal Base Shear:	1105 kips	



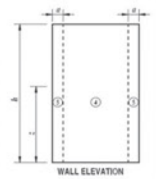
WINDWARD WIND LOAD
LOWER LEVELS

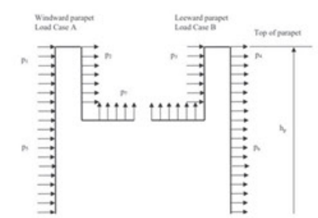


WINDWARD WIND LOAD
ALL LEVELS

COMPONENTS & CLADDING

STEP DESCRIPTION	COMPUTATION	50 ft²	500 ft²	REFERENCE
External Pressure Coefficient (GC_p)	Walls:			Figure 30.6-1
	Negative Zone 4:	-0.85	-0.70	
	Negative Zone 5:	-1.60	-1.00	
	Positive Zone 4 & 5:	0.80	0.60	
	Roof:			
	Negative Zone 1:	-1.20	-0.90	
	Negative Zone 2:	-2.00	-1.60	
	Negative Zone 3:	-2.80	-2.30	
Design Wind Pressures (p):	Walls:			
	Negative Zone 4:			
	Case 1: 15 ft.	-18.40 PSF	-15.72 PSF	
	Case 2: 18 ft.	-19.36 PSF	-16.54 PSF	
	Case 3: 35 ft.	-23.56 PSF	-20.13 PSF	
	Case 4: 51 ft.	-26.27 PSF	-22.45 PSF	
	Case 6: 65 ft.	-28.08 PSF	-23.99 PSF	
	Case 7: 83 ft.	-30.31 PSF	-25.89 PSF	
	Case 8: 97 ft.	-31.66 PSF	-27.05 PSF	
	Case 9: 111 ft.	-32.84 PSF	-28.06 PSF	
	Case 10: 125 ft.	-33.97 PSF	-29.02 PSF	
	Case 11: 143 ft.	-35.37 PSF	-30.22 PSF	
	Negative Zone 5:			
	Case 1: 15 ft.	-31.79 PSF	-21.08 PSF	
	Case 2: 18 ft.	-33.47 PSF	-22.18 PSF	
	Case 3: 35 ft.	-40.72 PSF	-26.99 PSF	
	Case 4: 51 ft.	-45.40 PSF	-30.10 PSF	
	Case 6: 65 ft.	-48.52 PSF	-32.17 PSF	
	Case 7: 83 ft.	-52.37 PSF	-34.72 PSF	
	Case 8: 97 ft.	-54.72 PSF	-36.27 PSF	
	Case 9: 111 ft.	-56.75 PSF	-37.62 PSF	
	Case 10: 125 ft.	-58.70 PSF	-38.92 PSF	
	Case 11: 143 ft.	-61.13 PSF	-40.52 PSF	
		50 ft²	500 ft²	
	Positive Zone 4 & 5:			
	Case 1: 15 ft.	17.50 PSF	13.93 PSF	
	Case 2: 18 ft.	18.42 PSF	14.66 PSF	
	Case 3: 35 ft.	22.42 PSF	17.84 PSF	
	Case 4: 51 ft.	25.00 PSF	19.89 PSF	
	Case 6: 65 ft.	26.72 PSF	21.26 PSF	
	Case 7: 83 ft.	28.83 PSF	22.95 PSF	
	Case 8: 97 ft.	30.12 PSF	23.98 PSF	
	Case 9: 111 ft.	31.25 PSF	24.87 PSF	
	Case 10: 125 ft.	32.32 PSF	25.72 PSF	
	Case 11: 143 ft.	33.66 PSF	26.79 PSF	
	Roof:			
	Negative Zone 1:			
	Case 5: 55 ft.	-35.89 PSF	-28.09 PSF	
	Case 12: 147 ft.	-47.74 PSF	-37.36 PSF	
	Negative Zone 2:			
	Case 5: 55 ft.	-56.70 PSF	-46.29 PSF	
	Case 12: 147 ft.	-75.41 PSF	-61.58 PSF	
	Negative Zone 3:			
	Case 5: 55 ft.	-77.50 PSF	-64.50 PSF	
	Case 12: 147 ft.	-103.09 PSF	-85.79 PSF	
		50 ft²	500 ft²	
	Parapet:			Figure 30.9-1
	Windward:			
	Lower Roof:	77.50 PSF	72.30 PSF	
	Upper Roof:	103.09 PSF	96.17 PSF	
	Leeward:			
	Lower Roof:	47.59 PSF	42.39 PSF	
	Upper Roof:	63.31 PSF	56.39 PSF	





VOIDED SLAB DESIGN

Self-Weight of Voided Slab

$V_{void} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(5")^3 = 523\ in^2$

$V_{total} = (14")(11")(11") = 1694\ in^2$

% Concrete Savings = 30.9 %

Equivalent Slab Thickness = (14")(1 - 0.309) = 9.68"

D = (150 PCF)(1 ft)(9.68/12 ft) = 121.0 PSF

Determine Tota Factored Static Moment in Each Span

$w_u = 1.2D + 1.6L = 1.2(120.9 + 20) + 1.6(50) = 249.1\ PSF$

$l_n = 32' - 4' = 28'$

$M_0 = \frac{w_u l_2 l_n^2}{8} = \frac{(249.1\ PSF)(33')(28')^2}{8} = 805.6\ k-ft$

Location			M_u (k-ft)	A_s (in^2)	Reinf.
End Span	Column Strip	Exterior Negative	209.5	4.84	11 # 6
		Positive	249.7	4.84	11 #6
		Interior Negative	427.0	7.92	18 #6
	Middle Strip	Exterior Negative	0.0	4.84	11 #6
		Positive	169.2	4.84	11 #6
		Interior Negative	137.0	4.84	11 #6
Interior Span	Column Strip	Positive	169.2	4.84	11 #6
		Negative	394.7	7.48	17 #6
	Middle Strip	Positive	112.8	4.84	11 #6
		Negative	128.9	4.84	11 #6

Required Reinforcement

d = 14" - 1.25" = 12.75"   b = 192"

$R_n = \frac{M_u}{\phi b d^2} = \frac{(427.0\ k-ft)(1000\frac{lb}{k})(12"/ft)}{0.9(192")(12.75")^2} = 182.4\ psi$

$\rho = \frac{0.85f'_c}{f_y}\left[1-\sqrt{1-\frac{2Rn}{0.85f'_c}}\right] = \frac{0.85(4)}{60}\left[1-\sqrt{1-\frac{2(182.4)}{0.85(4000)}}\right] = 0.0031$

$A_s = \rho bd = (0.0031)(192")(12.75") = 7.65\ in^2$

$A_{s\ min} = 0.0018bh = 0.0018(192")(14") = 4.84\ in^2$

Check Compression Block

$a = \frac{A_s f_y}{0.85f'_c b} = \frac{(7.65)(60)}{0.86(4)(192)} = 0.703"$

$c = \frac{a}{\beta_1} = \frac{0.703}{0.85} = 0.828" < 2"$ → GOOD

$\varepsilon_t = 0.003\left(\frac{d}{c}-1\right) = 0.003\left(\frac{12.75}{0.828}-1\right) = 0.0432$

Choose Reinforcement

→ USE **(18) #6 BARS**

$A_s = 7.92\ in^4$

Check Spacing at Critical Sections

$c_2 + 3h = 36" + 3(14") = 78"$

$b_1 = c_1 + \frac{d}{2} = 36" + \frac{12.75"}{2} = 42.375"$

$b_2 = c_2 + d = 36" + 12.75" = 48.75"$

$\gamma_f = \frac{1}{1+(\frac{2}{3})(\sqrt{b_1/b_2})} = 0.62$

$\gamma_f M_u = 0.62(209.5) = 129.9\ k-ft$

Use Minimum Reinforcement → 11 #6 Bars

78"/11 = 7.1" < 18" → OK

Two-Way Shear Design Capacity

$\phi V_c = \phi 4\lambda\sqrt{f'_c}b_0 d$

$= 0.75(4)(1.0)\sqrt{4000}[4(36+12.75)](12.75)\left(\frac{1}{1000}\right)$

$= 471.7\ k$

Solid Area Around Column

$A_{solid} = Tributary\ Area\ of\ Column - \frac{(Shear\ Reduction\ Factor)(Allowable\ Direct\ Shear\ Force)}{Total\ Factored\ Uniformly\ Distributed\ Load}$

$= (32' x\ 33') - \frac{(0.55)(471.7\ k)}{(0.2491\ ksi)} = 14.5\ ft^2$

Total Factored Sheared Stress

$V_u = qu(A_t - b_1 b_2)$

$= (0.249\ k)\left(560ft^2 - (42.375")(48.75")\left(\frac{1}{144}\right)\right) = 135.9\ k$

$A_t = \frac{32'}{2} + \frac{36"}{2\left(\frac{12"}{ft}\right)} = 560\ ft^2$

$\gamma_v = 1 - \gamma_f = 1 - 0.62 = 0.38$

$0.3M_0 = Mu = 0.3(781\ k-ft) = 234.3\ k-ft$

$J_c c_{AB} = \frac{2b_1^2 d(b_1+2b_2) + d^3(2b_1+b_2)}{6b_1} = 26{,}279\ in^3$

$v_u = \frac{V_u}{A_c} + \frac{\gamma_v M_u}{J_c c_{AB}} = \frac{135.9}{1702} + \frac{0.38(234.3)(12)}{26{,}279} = 120.5\ psi$

Allowable Shear Stress

$\phi V_c = \phi 4\lambda\sqrt{f'_c} = (0.75)(4)(1.0)\sqrt{4000} = 189.7\ psi$

$v_u < \phi V_c$ → OK

VOIDED SLAB DESIGN: MECHANICAL ROOM

Self-Weight of Voided Slab

$V_{void} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(5")^3 = 523\ in^2$

$V_{total} = (14")(11")(11") = 1694\ in^2$

% Concrete Savings = 30.9 %

Equivalent Slab Thickness = (14")(1 - 0.309) = 9.68"

D = (150 PCF)(1 ft)(9.68/12 ft) = 121.0 PSF

Determine Tota Factored Static Moment in Each Span

$w_u = 1.2D + 1.6L = 1.2(120.9 + 20) + 1.6(125) = 369.1\ PSF$

$l_n = 32' - 4' = 28'$

$M_0 = \frac{w_u l_2 l_n^2}{8} = \frac{(369.1\ PSF)(33')(28')^2}{8} = 1193.6\ k-ft$

Location			M_u (k-ft)	A_s (in^2)	Reinf.
End Span	Column Strip	Exterior Negative	-310.3		
		Positive	370.0		
		Interior Negative	-632.6	7.92	18 #6
	Middle Strip	Exterior Negative	0.0		
		Positive	250.7		
		Interior Negative	-202.9		
Interior Span	Column Strip	Positive	250.7		
		Negative	-584.9		
	Middle Strip	Positive	167.1		
		Negative	-191.0		

Required Reinforcement

d = 14" - 1.25" = 12.75"   b = 192"

$R_n = \frac{M_u}{\phi b d^2} = \frac{(632.6\ k-ft)(1000\frac{lb}{k})(12"/ft)}{0.9(192")(12.75")^2} = 270.2\ psi$

$\rho = \frac{0.85f'_c}{f_y}\left[1-\sqrt{1-\frac{2Rn}{0.85f'_c}}\right] = \frac{0.85(4)}{60}\left[1-\sqrt{1-\frac{2(270.2)}{0.85(4000)}}\right] = 0.0047$

$A_s = \rho bd = (0.0047)(192")(12.75") = 11.50\ in^2$

$A_{s\ min} = 0.0018bh = 0.0018(192")(14") = 4.84\ in^2$

Check Compression Block

$a = \frac{A_s f_y}{0.85f'_c b} = \frac{(11.5)(60)}{0.86(4)(192)} = 1.045"$

$c = \frac{a}{\beta_1} = \frac{1.045}{0.85} = 1.23" < 2"$ → OK

$\varepsilon_t = 0.003\left(\frac{d}{c}-1\right) = 0.003\left(\frac{12.75}{1.23}-1\right) = 0.0281$

Choose Reinforcement

→ USE **(27) #6 BARS**

$A_s = 11.88\ in^2$

Check Spacing at Critical Sections

$c_2 + 3h = 36" + 3(14") = 78"$

$b_1 = c_1 + \frac{d}{2} = 36" + \frac{12.75"}{2} = 42.375"$

$b_2 = c_2 + d = 36" + 12.75" = 48.75"$

$\gamma_f = \frac{1}{1+(\frac{2}{3})(\sqrt{b_1/b_2})} = 0.62$

$\gamma_f M_u = 0.62(310.3) = 192.4\ k-ft$

Use Minimum Reinforcement → 11 #6 Bars

78"/11 = 7.1" < 18" → OK

Two-Way Shear Design Capacity

$\phi V_c = \phi 4\lambda\sqrt{f'_c}b_0 d$

$= 0.75(4)(1.0)\sqrt{4000}[4(36+12.75)](12.75)\left(\frac{1}{1000}\right)$

$= 471.7\ k$

Solid Area Around Column

$A_{solid} = Tributary\ Area\ of\ Column - \frac{(Shear\ Reduction\ Factor)(Allowable\ Direct\ Shear\ Force)}{Total\ Factored\ Uniformly\ Distributed\ Load}$

$= (32' x\ 33') - \frac{(0.55)(471.7\ k)}{(0.3691\ ksi)} = 353\ ft^2$

Total Factored Sheared Stress

$V_u = qu(A_t - b_1 b_2)$

$= (0.369\ k)\left(560ft^2 - (42.375")(48.75")\left(\frac{1}{144}\right)\right) = 201.3\ k$

$A_t = \frac{32'}{2} + \frac{36"}{2\left(\frac{12"}{ft}\right)} = 560\ ft^2$

$\gamma_v = 1 - \gamma_f = 1 - 0.62 = 0.38$

$0.3M_0 = Mu = 0.3(1193.6\ k-ft) = 358.1\ k-ft$

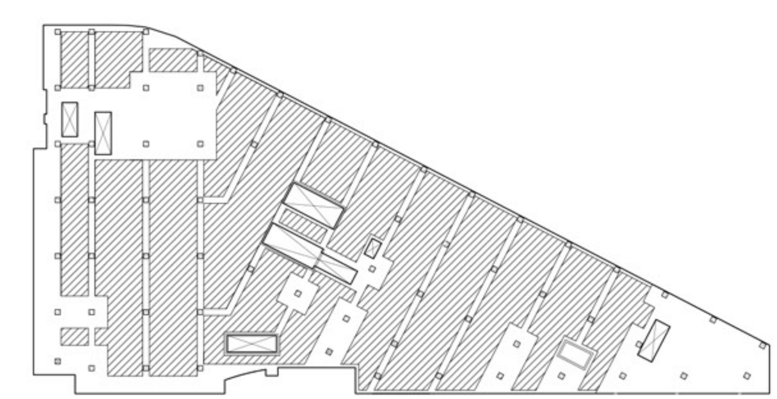
$J_c c_{AB} = \frac{2b_1^2 d(b_1+2b_2) + d^3(2b_1+b_2)}{6b_1} = 26{,}279\ in^3$

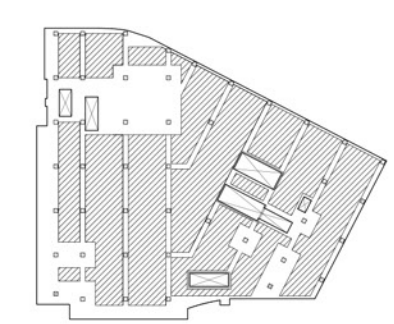
$v_u = \frac{V_u}{A_c} + \frac{\gamma_v M_u}{J_c c_{AB}} = \frac{201.3}{1702} + \frac{0.38(234.3)(12)}{26{,}279} = 158.9\ psi$

Allowable Shear Stress

$\phi V_c = \phi 4\lambda\sqrt{f'_c} = (0.75)(4)(1.0)\sqrt{4000} = 189.7\ psi$

$v_u < \phi V_c$ → OK





VOIDED SLAB

DRILLED PIER DESIGN

Step Description	Calculations	Reference
Parameters	**Column Parameters:** Size: 36" ϕ D: 36 in Pipe Area: 54.75 in^2 Gross Area: 1017.36 in^2 Net Area: 962.61 in^2 Properties: f'_c = 6,000 psi; f_y = 60,000 psi; E_s = 29,000 psi Maximum Concrete Strain ε_{max} = 0.003 in/in	
Determine Reinforcement	Transverse Reinforment: #3 @16" O.C. Longitudinal Renforcement: 9 #10 Area $_{bar}$ = 1.27 in^2 $Area_{provided}$ = 11.43 in^2 Area concrete = 951.18 in^2 Clear Cover = 2.5 in Edge Distance= 3.135 in Spacing = 10.32 in $A_{s\,min} = A_{gross}(0.01)$ $A_{s\,min} = (1018\,in^2)(0.01)$ $A_{s\,min}$ = 10.1736 in^2	
Analysis	**Axial Capcity:** (Pure Axial) $\emptyset P_n = \emptyset[(0.85)(f'_c)(A_g - A_s) + (A_s f_y)]$ $\emptyset = 0.7\ (Tied)$ $\emptyset P_n = 0.7[(0.85)(10{,}000\,psi)(1296\,in^2 - 15.6\,in^2) + (15.6\,in^2)(60{,}000\text{ psi})]$ $\emptyset P_n$ = 3875.76 kips Reducation of Axial Capacity = $(0.8)\emptyset P_n$ = 3100.61 kips **Moment Capacity:** Area of Rebar = 1.27 in^2 $a = \frac{(A_s)(f_y)}{(0.85)(f'_c)(d)}$ $a = \frac{(1.27\,in^2)(9\,Bars)(60{,}000\,psi)}{(0.85)(6{,}000\,psi)(36\,in)}$ a = 3.735 in $M_n = (A_s)(f_y)\left[d_1 - \left(\frac{a}{2}\right)\right]$ $M_n = (1.27\,in^2)(9\,Bars)(60{,}000\,psi)\left[32.9\,in - \left(\frac{3.375\,in}{2}\right)\right]$ M_n = 1771.50 kip-ft $\emptyset M_n = (0.9)(1771.5\,k-ft)$ $\emptyset M_n$ = 1594.35 kip-ft	

SHEAR WALL DESIGN

1. Initial Check of Wall Reinforcement

$$\rho_t = \frac{A_{v\,horiz}}{hs_2} = \frac{2(0.2\,in^2)}{(14")(18")} = 0.0016$$

$$\rho_l = \frac{A_{v\,vert}}{hs_1} = \frac{2(1.0\,in^2)}{(14")(12")} = 0.0119$$

2. Check Moment Strength

$$M_{base} = 14{,}653\,k-ft$$

$$M_u = 0.9D + 1.0W$$

$$M_u = 1.0(14{,}653\,k-ft) = 14{,}653\,k-ft$$

$$N_u = 0.9ND = 0.9(747.4\,k) = 672.7\,k$$

$$w = pl\frac{f_y}{f'_c} = (0.0119)\left(\frac{60}{8}\right) = 0.0893$$

$$\alpha = \frac{N_u}{hl_w f'_c} = \frac{672.7\,k}{(14)(186)(8\,ksi)} = 0.0323"$$

$$c = \left(\frac{\alpha + w}{0.85\beta_1 + 2w}\right)l_w = \left(\frac{0.0323 + 0.0893}{0.85(0.65) + 2(0.0893)}\right)(186") = 30.9"$$

$$d = 0.8lw = 0.8(186) = 148.8" \rightarrow c < 0.375d \rightarrow tension-controlled\ section$$

$$A_{st} = 2Ab\frac{l_w}{s_1} = 2(1.0\,in^2)\frac{186"}{12"} = 31.0\,in^2$$

$$T = Astf_y\left(\frac{l_w - c}{l_w}\right) = (31.0\,in^2)(60\,ksi)\left(\frac{186" - 30.9"}{186"}\right) = 1551\,k$$

$$M_n = T\left(\frac{l_w}{2}\right) + Nu\left(\frac{l_w - c}{l_w}\right) = (1551\,k)\left(\frac{186"}{2}\right) + (673\,k)\left(\frac{186" - 30.9"}{186"}\right) = 16{,}370\,k-ft$$

$$\phi M_n = 0.9(16{,}370\,k-ft) = 14{,}733\,k-ft > Mu = 14{,}653\,k-ft$$

3. Check Shear Strength

$$V_{base} = 147\,k$$

$$V_u = 0.9D + 1.0W = 1.0(147\,k) = 147\,k$$

$$V_c = 3.3\lambda\sqrt{f'_c}hd + \frac{N_u d}{4lw} = 3.3(1.0)\sqrt{8000\,psi}(14")(148.8") + \frac{(672.7\,k)(148.8")}{4(186")} = 749.5\,k$$

Critical Section Above Base of Wall

Smallest of:

$$\frac{l_w}{2} = 7.75' \quad (GOVERNS)$$

$$\frac{h_w}{2} = 82.5'$$

$$One - Story\ Height = 22'$$

$$M_{u(crit)} = Mu_{(base)} - Vu_{(base)}\frac{l_w}{2} = (14{,}653\,k-ft) - (147\,k)\frac{15.5\,ft}{2} = 13{,}514\,k-ft$$

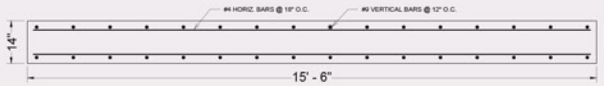
$$\frac{M_u}{V_u} = \frac{13{,}514\,k-ft}{147\,k} = 91.9\,ft$$

$$V_c = \left[0.6\lambda\sqrt{f'_c} + \frac{l_w(1.25\lambda\sqrt{f'_c} + 0.2\frac{N_u}{l_w h})}{\frac{M_u}{V_u} - \frac{l_w}{2}}\right]hd = 174.5\,k$$

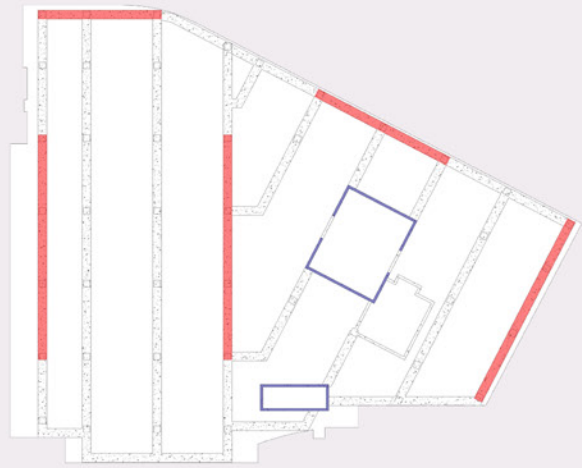
$$\phi V_c = 0.75(174.5\,k-ft) = 130.9\,k < Vu = 147\,k$$

$$V_{s\,equiv} = \frac{A_{v\,horizfyt}l_w}{s_2} = \frac{2(0.2\,in^2)(60\,ksi)(186")}{18"} = 248\,k$$

$$\phi V_n = \phi(V_c + Vs) = 0.75(174.5\,k) = 317\,k$$



MOMENT FRAME
SHEAR WALL



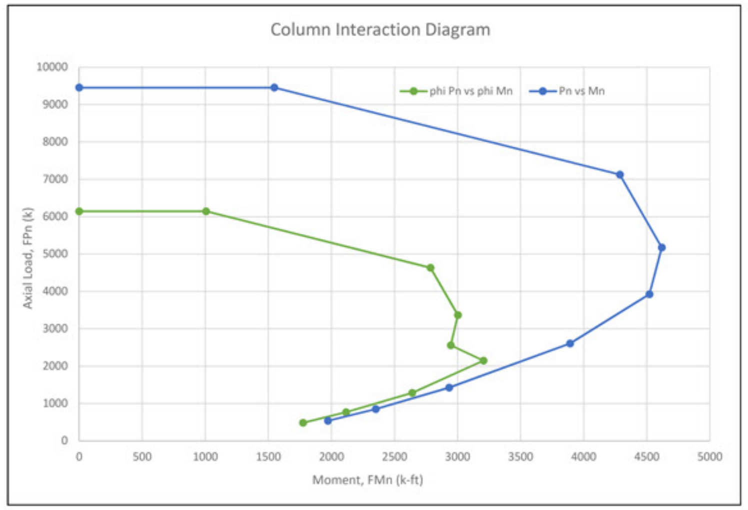
REINFORCED CONCRETE COLUMN DESIGN

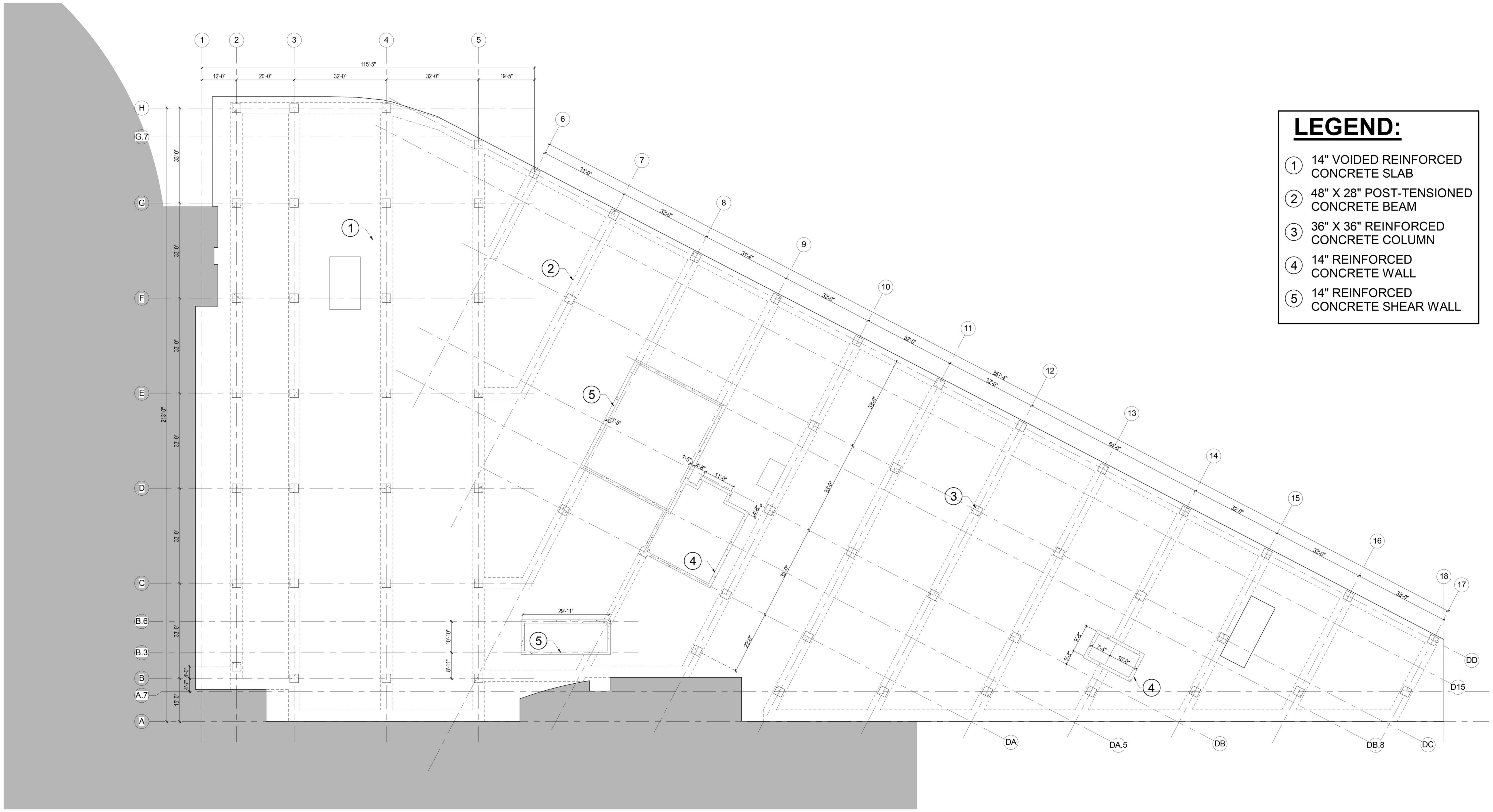
Step Description	Calculations
Known Information	**Column Parameters:** Size: 36" x 36" B: 36 in H: 36 in Total Area: 1296 in^2 Transverse Reinforment: #4 Longitudinal Renforcement: 10#11 Area = 1.56 in^2 $Area_{provided}$ = 15.6 in^2 Gross Area = 1280.4 in^2 Layout of Column: D1: 33.5 in; D2: 23.17 in; D3: 12.83 in; D4: 2.50 Properties: f'_c = 10,000 psi; f_y = 60,000 psi; E_s = 29,000 psi Maximum Concrete Strain ε_{max} = 0.003 in/in Edge Distance = 2.5 in Spacing = 10.33 in $A_{s\,min} = A_{net}(0.01)$ $A_{s\,min} = (1296\,in^2)(0.01)$ $A_{s\,min}$ = 12.96 in^2
Analysis	**Axial Capeity:** (Pure Axial) $\emptyset P_n = \emptyset[(0.85)(f'_c)(A_g - A_s) + (A_s f_y)]$ $\emptyset = 0.7\ (Tied)$ $\emptyset P_n = 0.7[(0.85)(10{,}000\,psi)(1296\,in^2 - 15.6\,in^2) + (15.6\,in^2)(60{,}000\text{ psi})]$ $\emptyset P_n$ = 8273.58 kips Reducation of Axial Capacity = $(0.8)\emptyset P_n$ = 6618.86 kips **Moment Capcaity:** Area of Rebar = 1.56 in^2 $a = \frac{(A_s)(f_y)}{(0.85)(f'_c)(B)}$ $a = \frac{(1.56\,in^2)(3\,Bars)(60{,}000\,psi)}{(0.85)(10{,}000\,psi)(36\,in)}$ a = 0.918 in $M_n = (A_s)(f_y)\left[d_1 - \left(\frac{a}{2}\right)\right]$ $M_n = (1.56\,in^2)(3\,Bars)(60{,}000\,psi)\left[33.5\,in - \left(\frac{0.918\,in}{2}\right)\right]$ M_n = 773.16 kip-ft $\emptyset M_n = (0.9)(773.16\,k-ft)$ $\emptyset M_n$ = 695.85 kip-ft

Interaction Diagram

Interaction Diagram Data

ε_s	Pn	Mn	Φ	ΦP_n	ΦM_n
	k	k-ft		k	k-ft
-0.003	-11,819	0	0.650	-7,683	0
-0.001	-10,649	-1,547	0.650	-6,922	-1,006
0.000	-7,127	-4,286	0.650	-4,632	-2,786
0.00103	-5,178	-4,619	0.650	-3,366	-3,002
0.00207	-3,926	-4,520	0.652	-2,559	-2,946
0.00414	-2,609	-3,892	0.823	-2,148	-3,205
0.00828	-1,426	-2,934	0.900	-1,283	-2,640
0.01241	-852	-2,351	0.900	-767	-2,116
0.0166	-536	-1,972	0.900	-483	-1,775





LEGEND:

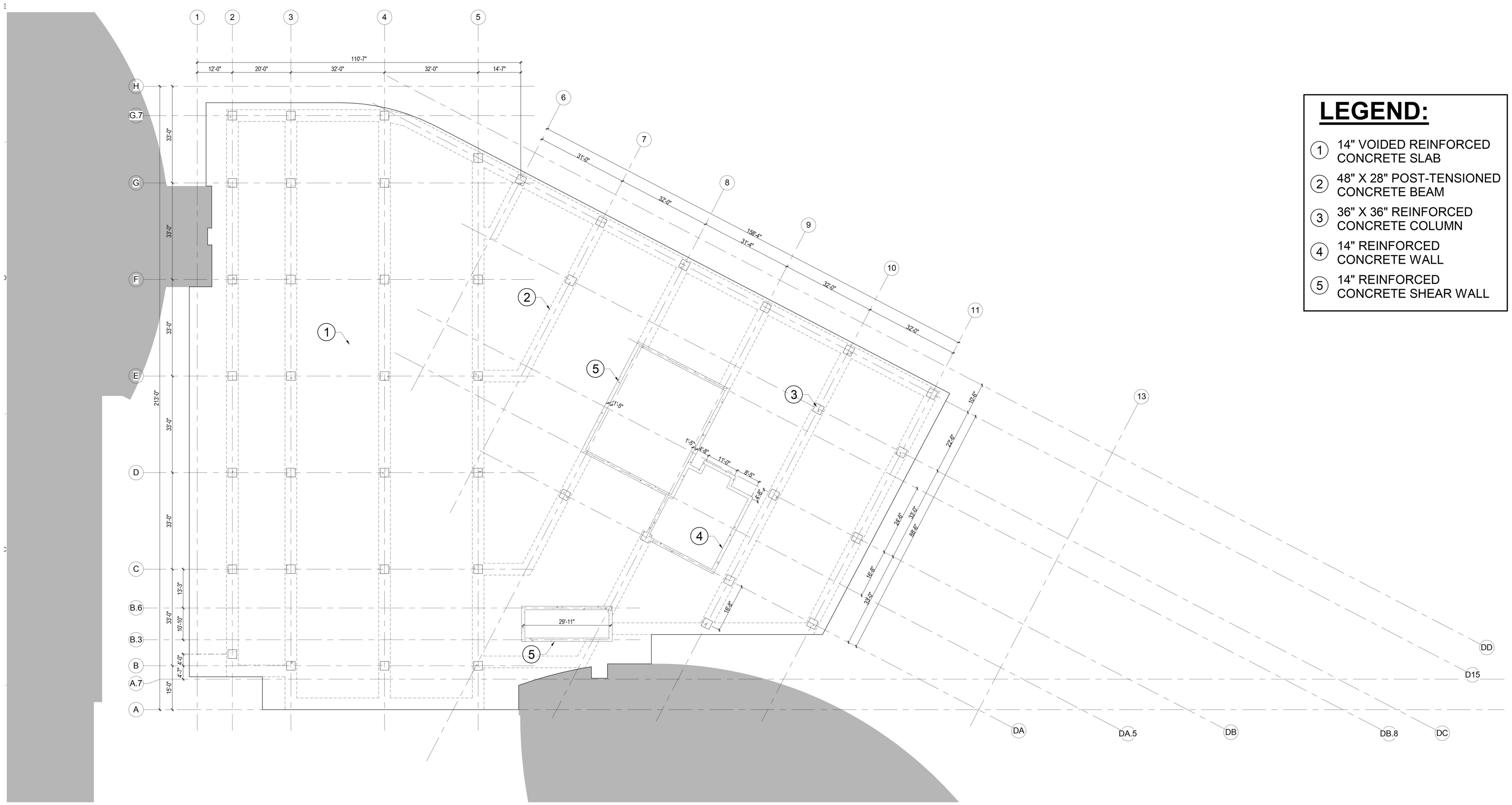
1. 14" VOIDED REINFORCED CONCRETE SLAB
2. 48" X 28" POST-TENSIONED CONCRETE BEAM
3. 36" X 36" REINFORCED CONCRETE COLUMN
4. 14" REINFORCED CONCRETE WALL
5. 14" REINFORCED CONCRETE SHEAR WALL

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
TYPICAL LOWER LEVEL FRAMING PLAN

S-102



LEGEND:

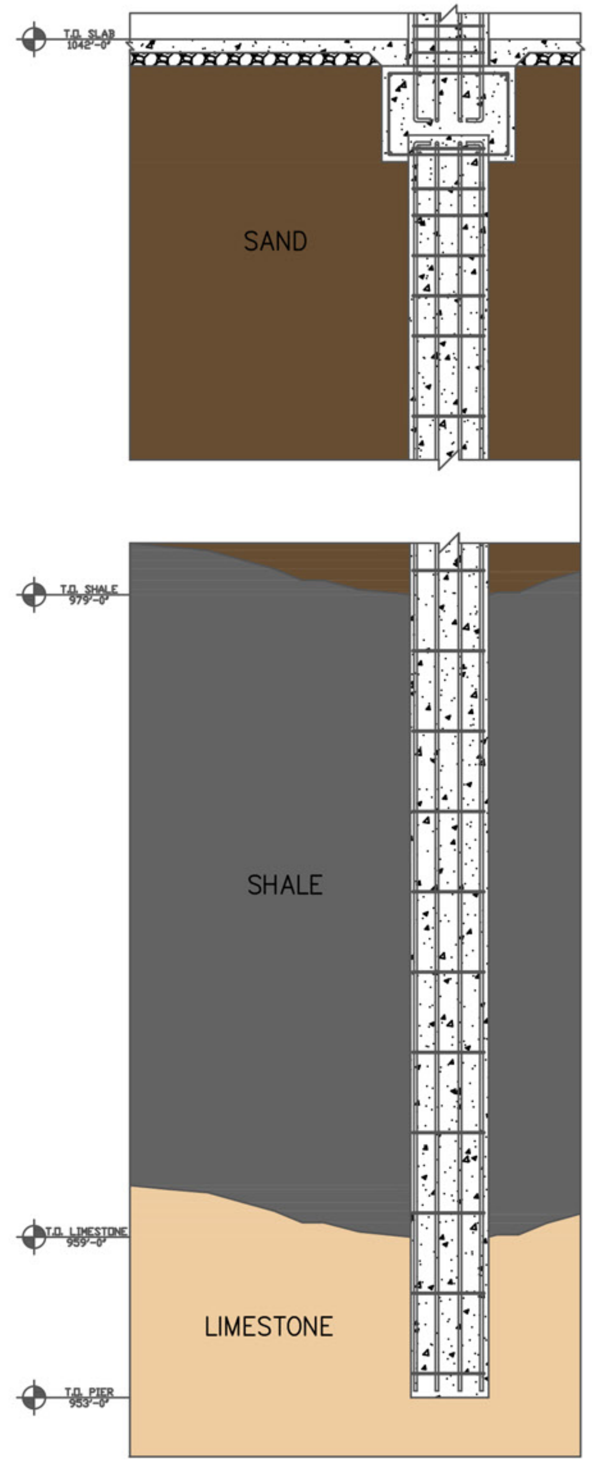
1. 14" VOIDED REINFORCED CONCRETE SLAB
2. 48" X 28" POST-TENSIONED CONCRETE BEAM
3. 36" X 36" REINFORCED CONCRETE COLUMN
4. 14" REINFORCED CONCRETE WALL
5. 14" REINFORCED CONCRETE SHEAR WALL

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
TYPICAL TOWER LEVEL FRAMING PLAN

S-103



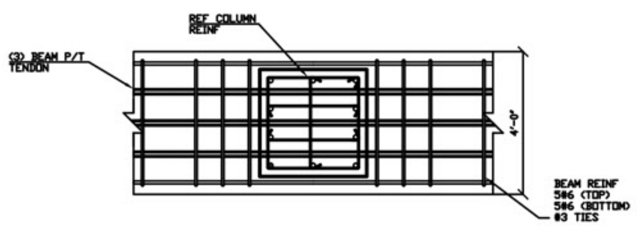
SOIL ELEVATION (A)
NO SCALE

MUREX
EST 2017-18

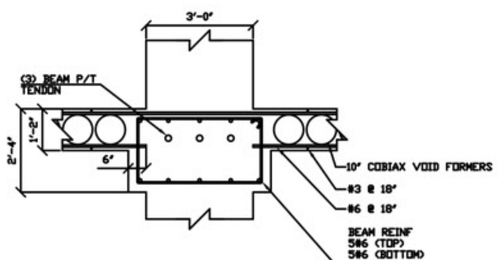
PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
SECTIONS

S-201

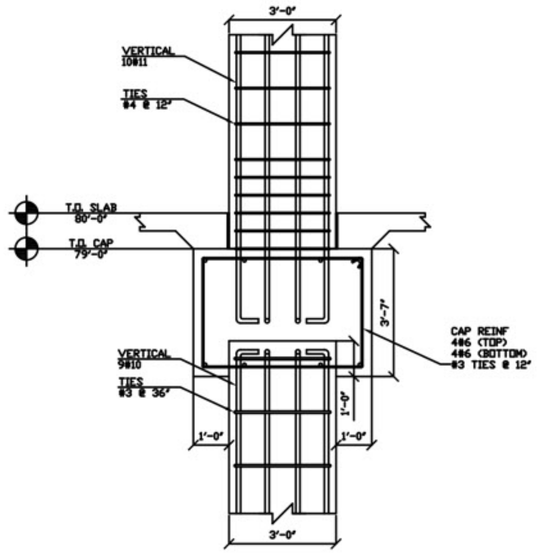


TYPICAL PLAN COLUMN BEAM DETAIL (A)
NO SCALE

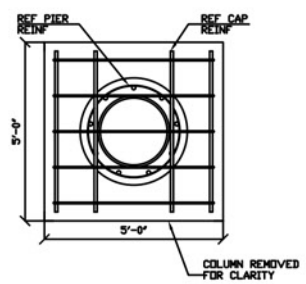


TYPICAL COLUMN BEAM DETAIL (D)
NO SCALE

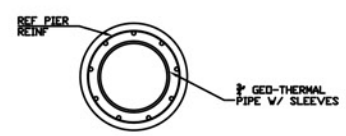
NOTES:
MINIMUM EXTERIOR CLEAR COVER OF 3"



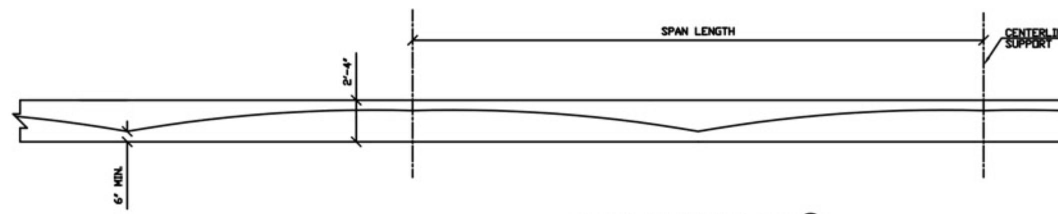
TYPICAL COLUMN PIER DETAIL (B)
NO SCALE



TYPICAL PLAN PIER CAP DETAIL (E)
NO SCALE



TYPICAL PIER DETAIL (G)
NO SCALE



TYPICAL 3-INTERIOR SPAN (C)
NO SCALE

STRESSING ANCHORAGE

FIXED ANCHORAGE

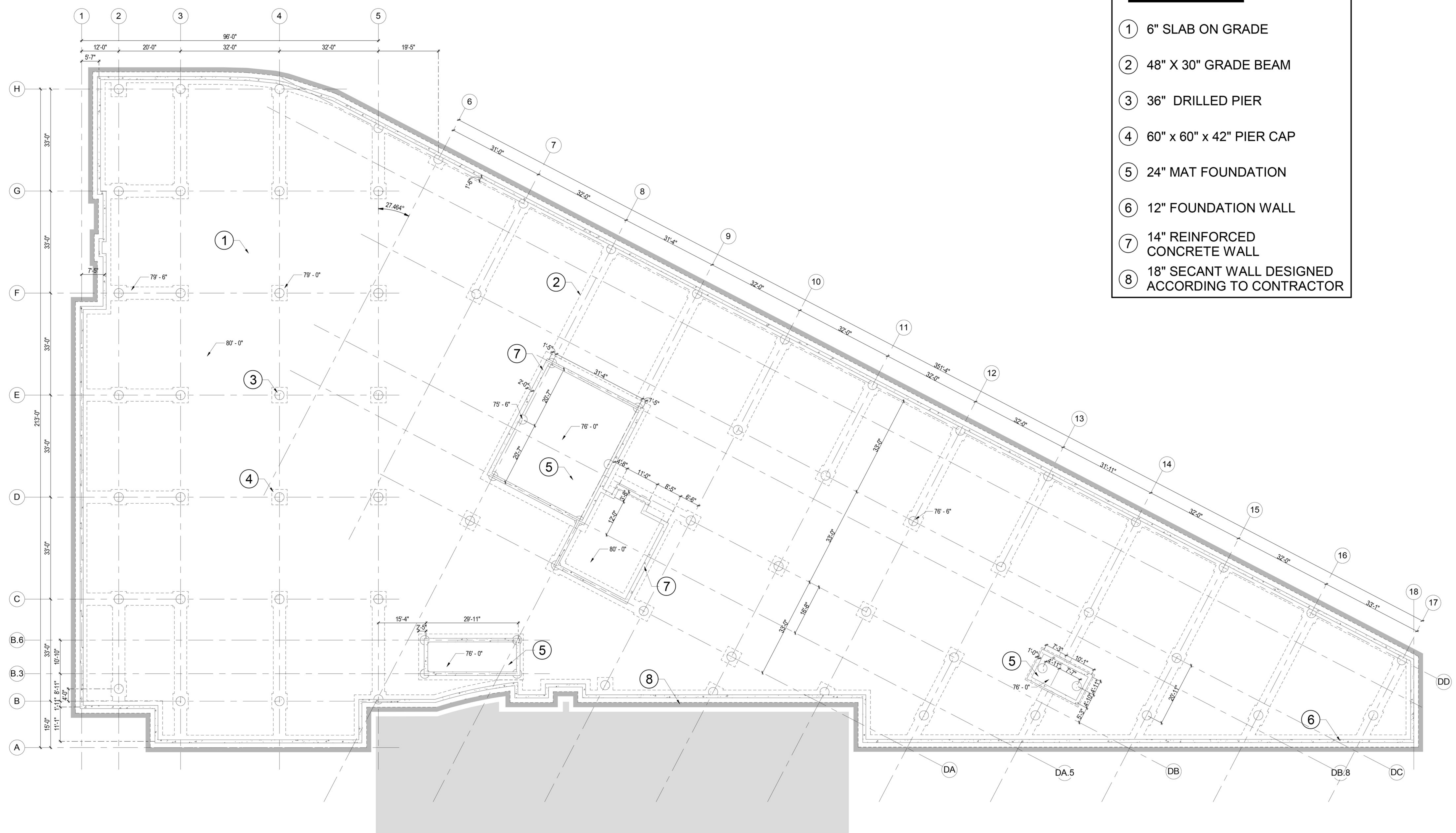
TYPICAL POST-TENSION BEAM ANCHORAGE DETAILS (F)
NO SCALE

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
TYPICAL DETAILS

S-501



LEGEND:

1. 6" SLAB ON GRADE
2. 48" X 30" GRADE BEAM
3. 36" DRILLED PIER
4. 60" x 60" x 42" PIER CAP
5. 24" MAT FOUNDATION
6. 12" FOUNDATION WALL
7. 14" REINFORCED CONCRETE WALL
8. 18" SECANT WALL DESIGNED ACCORDING TO CONTRACTOR

A
S-101

FOUNDATION PLAN

SCALE 1/16" = 1'-0"

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
FOUNDATION PLAN

S-101

3.1.0 Executive Summary

Murex has provided the preliminary design for the Children's Hospital and Medical Center in Omaha, Nebraska. This project submittal will cover all HVAC system designs, plumbing designs, and the integration of all disciplines with the mechanical systems at the Design Development level.

3.1.1 Introduction

The goals and designs of Murex are based on the principles of safety, integrity, and sustainability as outlined in the Architectural Engineering Institute Build Initiative. Murex believes these initiatives best serve the interest of the building owner and the community the building will affect. It is our goal to provide a design that has a positive and lasting impact for all who come in contact with it.

3.1.2 Project Description

The facility is a new construction building on the existing campus. It provides additions to the NICU and PICU units and a new Cardiac Care Center, and Fetal Care Program. This new ten-story tower and four-story ancillary podium project site is located adjacent to West Dodge Road, one of the busiest roads in the city. Throughout the mechanical design, Murex wanted to deliver solutions to the overall project challenges set, as well as align with individual team goals. With this in mind, Murex has focused its design on maximizing safety, integrity, and sustainability to create a cohesive, efficient design.

3.1.3 Design Goals

maingoals

1. Provide a building that has the capacity to serve any potential growth and development this building may see, as well as some potential growth outside of this building.
2. Provide a design that allows for a comfortable and personalized experience for each patient and their visiting family members.

subgoals

Highly Efficient Systems
The equipment chosen for this system is highly efficient due to the round the clock service required.

Reliability
The design is full of redundancy to provide a system that can withstand emergencies and equipment malfunctions.

Cost Effective Choices
With a focus one midwest sensibility, cost justification for all decisions is a major factor for design.

Patient Control and Comfort
The first and foremost concern of the hospital staff is to provide top of the line care to its patients. To enhance this experience, the patients have freedom in the rooms to fit their needs.

3.1.4 Design Solution

The Murex design team carefully selected the components of the design in cooperation with all disciplines to find solutions that complimented each others' systems.

Energy Piles

In collaboration with the structural team, the design incorporated a spiral ground source loop into the drilled piers. This provided a cost-effective renewable resource for cooling without requiring additional earthwork. The ground source loop will be implemented as part of the refrigeration cycle to minimize the usage of the cooling tower.

The basis for the design develops from the economic sensibility of geothermal thermal systems in the Midwest, but due to site and budget constraints in comparison to the load requirements, a standard system would not be appropriate. This realization, in collaboration with the structural team's drilled pier foundation design, is what constituted the research into ground source loops within concrete foundations.

The mechanical team has determined the design and capacity for the 65 slinky loops. The system's capacity can serve approximately 26% of the required heat exchange when the system runs at its peak cooling load by implementing this ground source loop strategy.

3. MECHANICAL NARRATIVE

3.1.0 Executive Summary
3.2.0 Project Introduction
3.2.1 Goals
3.2.2 AEI Build Initiatives
3.2.3 Challenges
3.3.0 Design Criteria
3.3.1 Codes & Standards
3.3.2 Integrated Project Delivery (IPD)
3.3.3 Set Point Conditions
3.4.0 Hvac System
3.4.1 Geothermal Piers
3.4.2 Central Plant Design
3.5.0 Air Distribution
3.5.1 Air Flow Path
3.5.2 Ventilation Requirements
3.5.3 Relief and Toilet Exhaust
3.5.4 Venturi Valves
3.5.5 Vibration Isoation
3.5.6 Acoustic Control
3.6.0 Enclosure
3.6.1 Vertical Exterior Facade
3.6.2 Roof Enclosure
3.6.3 Clean Roof
3.7.0 Pressurization
3.7.1 Building Pressurization
3.7.2 Stair Pressurization
3.7.3 Specific Rooms
3.8.0 Plumbing Design
3.8.1 Domestic Water Service
3.8.2 Sanitary Drainage
3.8.3 Natural Gas
3.8.4 Hot Water Heaters
3.8.5 Roof Drainage
3.8.6 Fire Protection
3.8.7 Medical Gas
3.8.8 Compressed Medical Air
3.8.9 Vacuum
3.8.10 Sterillization
3.9.0 Controls & Building Monitoring System
3.10.0 Tornado Shelter / Refuge Design
3.11.0 Conclusion

3.2.0 Introduction

The 2018 AEI Student Design Competition project is Children's Hospital and Medical Center located along West Dodge Road in Omaha, Nebraska. The building is a four-story podium with a ten-story tower. The building is approximately 460,000 square feet with NICU, PICU, Fetal Care, Cardiac Care, Hematology/Oncology floors with a mechanical penthouse level in the tower. The base includes a mechanical and pharmacy level, a trauma level, OR spaces, and office area throughout. The scope of the project is to complete the design through Design Development. This submittal will address the opportunities and challenges that informed the mechanical system solutions and schemes arrived at by Murex.

3.2.1 Goals

The primary goals of the Murex mechanical design team are to maximize safety, integrity, and sustainability. The three of these concepts are used to create a cohesive, efficient design. These goals were selected for the following reasons:

Safety

To emphasize the role of the facility in the community and focus on patients, the design maximizes infection control in the equipment chosen, create environments where medical services can be provided as required and incorporates the services for tornado refuge and shelter.

Integrity

The team designed at a high caliber level while maintaining cost efficacy. The integration of all systems was paramount to supply quality work to meet and surpass the needs of the patients.

Sustainability

The design focuses on using resources wisely and providing long-lasting quality. The decisions made on the project were energy efficient to meet needs of the hospital and keep it running smoothly with the best case scenario life-cycle cost, rather than designing to meet a standard like LEED to showcase a plaque on the wall.

3.2.2 AEI Build Initiatives

The AEI Build Initiatives include eight areas of focus within the Architectural Engineering profession to aim to improve the design, maintenance, and construction of integrated buildings. The Murex design works to incorporate all of these through the goals set.

3.2.3 Challenges

The overall project challenges were addressed by the Murex mechanical team. They are covered in detail in other sections, but brief summaries are provided below.

- ENCLOSURE: The enclosure choice of a rear-ventilated wall provides a thermal shield to keep temperatures constant for longer, decreasing the mechanical load. By coordinating window locations with the facade, internal loads have been determined to choose properly sized, energy efficient equipment for the system.
- SMART BUILDING INTEGRATION: The building control and monitoring system provides the hospital with the ability to control aspects throughout a single system and track efficiency. Room controls integrated with this system allow for individualized patient
- DISASTER RESPONSE PLANNING: The mechanical systems have been designed to provide heating and cooling for the tornado shelter and refuges in case of an emergency. They are also designed to keep building pressurization in the stairwell during all emergencies to keep the air clean for the occupants.

The other challenges the mechanical design team faced are as follows:

- When determining equipment locations, the site presented limited options. With surrounding buildings, a busy, adjacent street, a future parking garage, and the need for a clean roof for the helipad, detailed coordination was required throughout the process.
- Compiling the HVAC restrictions and guidelines for the specified hospital spaces was an intensive process to develop the design for the project. Taking the time to slowly work through everything and double check the calculations and components was key to catching any possible mistakes early on in the design.
- Determining the best solution to provide adequate redundancy for the system resulted in always having the primary by splitting the load of the patient spaces across at least two AHUs
- Identifying the best innovative solution that promotes efficiency and maintaining redundancy and minimal risk in the hospital for purposes of infection control and patient health and safety.

3.3.0 Design Criteria

3.3.1 Codes & Standards

Omaha has adopted the Omaha Municipal Code, which encompasses the 2006 IMC and the 2015 Omaha Plumbing Code. The mechanical system design will be done in compliance with the Nebraska state codes as well as the following conditions and standards:2006 IMC

- 2000 LSC
- 2012 IFC
- ASHRAE Standard 62.1
- ASHRAE Standard 170
- 2013 ASHRAE Standard 90.1
- ASHRAE Standard 55
- ASHRAE Principle of Heating, Ventilation and Air-Conditioning, 7th Edition
- HVAC Design Manual for Hospitals and Clinics, 2nd Edition
- 2010 Closed-Loop/Geothermal Heat Pump Systems Design and Installations
- Closed-Loop Geothermal Systems Slinky Installation Guide
- 2015 Omaha Plumbing Code
- 2012 IPC
- 2012 IFGC
- 2015 NFPA 99
- 2016 NFPA 55
- FGI 2014 Guidelines for Design and Construction of Hospitals and Outpatient Facilities

3.3.2 Integrated Project Delivery (IPD)

For this project, Murex utilized the Integrated Project Delivery Method. This method allows the mechanical design to be involved with the other disciplines during the entire design phase of the project. This delivery method worked well as the design called for interdisciplinary coordination, such as the energy piles and equipment locations due to space limitations. IPD allowed for quick response times to constant design changes. By using the IPD method, the mechanical team was able to design Lower Level 5 with the electrical team to properly locate all mechanical and electrical equipment. Having the contractors on board during the design process is valuable as feasibility questions come into play with the project site, the budget is changing and value engineering options can be immediately discussed.

The team used the IPD method to ensure we were staying true to the AEI Build Initiatives. In meetings, members were reminded to keep these initiatives in mind when researching and developing the building systems and design.

3.3.3 Set Point Conditions

In the figure below, the conditions the mechanical team designed the space for is shown. The setpoint was based on ASHRAE Standard 62.1.

	COOLING		HEATING
Outdoor Air	90.0 °F DB	74.6 °F	-6.1 °F
Thermostat			
NICU Patient Rooms	76.0 °F DB	50% RH	76.0 °F DB
Operating Rooms	70.0 °F DB	50% RH	70.0 °F DB
All Other Spaces	72.0 °F DB	50% RH	72.0 °F DB

3.4.0 HVAC Systems

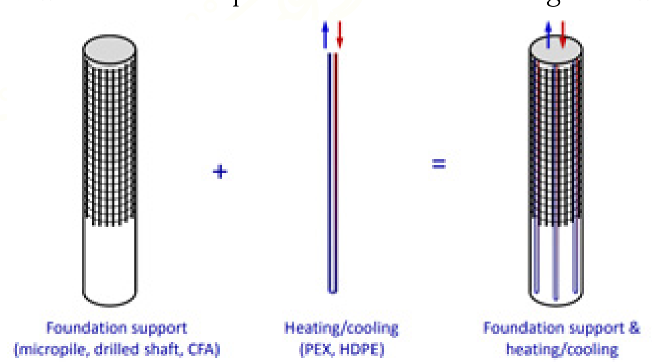
The loads for this building were calculated using Trane Trace 700. The outputs for the central plant sizing can be seen on page (Pg 58). Spreadsheets located on (Pg 58) show additional calculations for air totals, heating and cooling coils air handling units sizes, outside air requirements, and exhaust air requirements.

Many different solutions were considered including a radiant system, however, many systems are not appropriate to maintain the level of filtration and sanitation needed in a hospital without high risk and exorbitant cost. Creativity from the Murex team led to our approach of an innovative solution to the mechanical system while incorporating appropriate redundancy.

3.4.1 Geothermal Piers

This section will cover the effectiveness of the geothermal piers and the reason the system was selected for the Children's Hospital and Medical Center. In collaboration with the structural team, the design incorporated a spiral ground source loop into the drilled piers. This provides a cost-effective renewable resource for cooling without requiring additional earthwork. While other renewable energy resources were considered (such as PV: cells, windows, or facade), the payback for the initial cost could not be justified when trying to meet a large portion of the demand load. A geothermal thermal system is a practical solution for the Midwestern location of the facility.

The development of the ground-source loop concept develops as a result of the site and budget constraints when considering the load requirements. The mechanical team is working with the structural team to determine the appropriate locations for wells in relation to the structural piers. The additional earthwork and coordination that would be required to implement this system are over complicated and not cost-justifiable. The mechanical team performed more research into other solutions, which led to the concept of the energy piles, where the geothermal run is inside of the structural foundation. The break down of the concept can be seen in the image below.



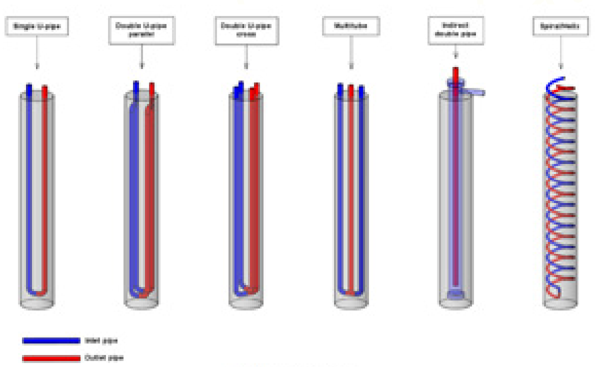
This structure is cost effective due to the Murex construction team already performing earthwork to this depth. The additional manpower required in this process will be attaching the piping to the rebar cages and fusing the sections together as the cages are placed in the boreholes.

The mechanical team's basis for design is an imperative part of the structural design, where the runs are already located at certain positions below the building and at specified depths. From here, the process required calculations to determine system capacity. There are 72 drilled piers and each descends 89 feet below the slab on grade with a diameter of 3 feet. However, some are too close together to each have a ground-source loop and maintain efficiency. The mechanical team chose to design for 65 energy piles. See sheet (Pg 59) for the geothermal plan.

The team considered running the length of the energy foundation further than the 89 feet of the drilled shafts, however the cost of increased earth work and additional concrete and rebar usage resulted in a value engineering decision to maintain the standard design and focus budget on aspects of the hospital that more directly relate to patient care and experience.

The first set of calculations are based on a vertical run of the pipe in 2 sets per structural pile. However, this resulted in a maximum capacity of 60 tons. Refer to page 59 to see geothermal pier calculations.

Further research led to additional layouts for energy piles. The graphic below shows potential pile configurations in drilled piers. The spiral or helix formation could provide additional linear footage to increase the capacity.



Research shows the spiral loop, often called the slinky loop, provides a simple installation by following design and installation guides.

Using the 2010 Closed-Loop/Geothermal Heat Pump Systems Design and Installations and the Closed-Loop Geothermal Systems Slinky Installation Guide from the International Ground Source Heat Pump Association, the mechanical team determines the design and capacity for the 65 slinky loops. Each energy pile extends 89 feet with a 3-foot diameter concrete structure that encases a vertical slinky run with a 2 feet diameter, and 6 inches of clearance is required from the edge of the pier.

The system's capacity can serve approximately 27% of the required heat exchange when the system runs at its peak cooling load by implementing this ground source loop strategy. Refer to page 59 to see geothermal pier calculations.

The cooling tower will provide the required heat exchange of the water that cannot be met by the ground loop to provide consistency and meet any future needs the hospital may produce. A oneline diagram of this system can be seen on page 69.

3.4.2 Central Plant Design

Since this building is being treated as a separate facility on the existing hospital campus, it shall have a standalone water-cooled central plant and gas-fueled boiler system. The central plant will be located on Lower Level 5. The mechanical central plant design involves two water-cooled chillers, one cooling tower located on the lower roof at the elevation of Level 2, two gas-fueled boilers, and a ground source loop. The ground source loop is used to as an alternative to the cooling tower by using the earth as a heat sink for the water.

3.4.1.1 Cooling Source

The cooling system is provided by two (2) 850-ton nominal water-cooled chillers with VFDs. This provides 75% redundancy. There will be one (1) 800-ton single cell cooling tower located on the lower roof, which is located in line with Level 2. Two (2) 2500 GPM split coupled vertical inline condensing pumps will be installed (with VFDs for soft start). Two (2) 1750 GPM split coupled vertical inline primary chilled water pumps are selected with VFDs. One pump on each is system is for redundancy. Flow meters will be provided in the chilled water supply pipes before exiting the central plant. Controls will be programmed to run pumps on a schedule to maintain even wear on all components.

3.4.1.2 Heating Source

The heating system is provided by two (2) 23,287 MBH gas fired boilers in the central plant in a rated room separate from chillers. Two (2) 2500 GPM split coupled vertical inline boiler pumps will be installed with VFDs. This allows the pumps to cycle and reduces strain on a single pump while providing 85% redundancy. Flow meters will be provided in the heating water supply pipes before exiting the central plant.

3.4.1.3 Chilled and Heating Water Distribution to the Building

Chilled water will be distributed to all levels of the hospital facility at an entering water temperature of 42 degrees. Piping-main locations will be coordinated with slab voids on each level. Runs to upper floors will occur in the chases. All chilled and heating water piping shall be Schedule 40 black steel, US domestic manufactured.

3.4.1.4 Air Handling Systems

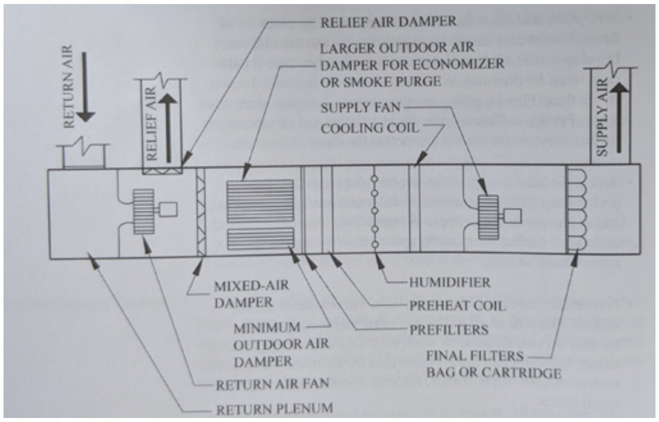
The facility shall be served by chilled water AHUs with VAV reheat boxes. Due to the nature of the facility, some of the AHUs will serve 100% outside air and others will meet the minimum requirement for outside air for each area served according to Chapter 4 of the IMC and be equipped with economizers. All units have been selected and located in a manner that simplifies maintenance and filter replacements. See page 60 attached for equipment schedules.

3.4.1.4.1 100% Outside Air Units

The 100% outside air AHUs shall be medium pressure, double wall, VAV Air-Handling Units with outside air dampers, MERV 8 pre-filters, MERV 14 final filters, a gas humidifier, a hot water preheat coil, a chilled water cooling coil, a hot water reheat coil, a UV filter across coils, and a fan array controlled by ECM motors.

3.4.1.4.2 All Other Units

The other AHUs shall be double wall, VAV Air-Handling Units with an economizer to control outside air dampers, an air flow station on the OA damper section, MERV 8 pre-filters, MERV 14 final filters, a gas humidifier, a hot water preheat coil, a chilled water cooling coil, a hot water reheat coil, a UV filter across coils, and a fan array controlled by ECM motors. The graphic below shows the makeup of one of these units.



3.5.0 Air Distribution

The air distribution design optimizes flexibility in the hospital while minimizing the spread of infection.

3.5.1 Air Flow Path

The air flow path for the building starts with the air handlers and is distributed downstream. The Murex team provided specific air flow path descriptions for common spaces in the pediatric facility.

3.5.1.1 Inpatient Spaces

The air handling units that supply all of the patient areas are 100% OA to eliminate the potential for contamination, with a positive pressurization. The flow path for this type of space will have outside air brought in by the unit and properly conditioned before flowing through the individual room's reheat VAV box, which can be tempered according to the patient. The air is then supplied to the space. The air will not return to this specified unit, as it is 100% outside air, but will escape the room through bathroom exhaust, exfiltrate through the envelope or transfer to the adjacent corridor, where it may be relieved or returned and filtered. While the photo in this section does not represent all patient rooms, the portion of the photo that shows the patient room and the attached bathroom is a correct representation. However, the air escapes into the corridor, rather than an anteroom.

The patient rooms in the facility that have anterooms attached are for highly infectious patients. The air flow in the anterooms controls the removal of all contaminants from the patient room and preventing the spread throughout the hospital. The bathroom exhaust system removes all air from the space. The image below shows the air flow path in these spaces.

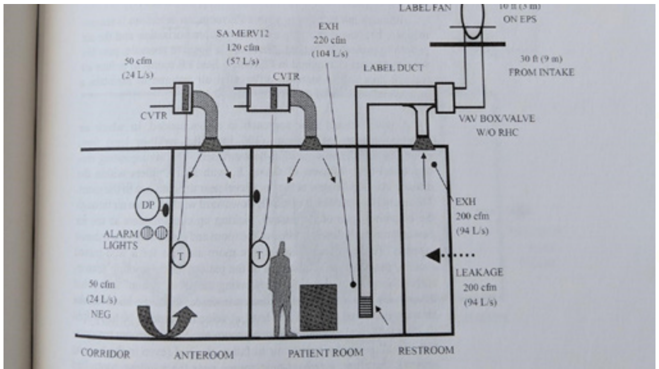
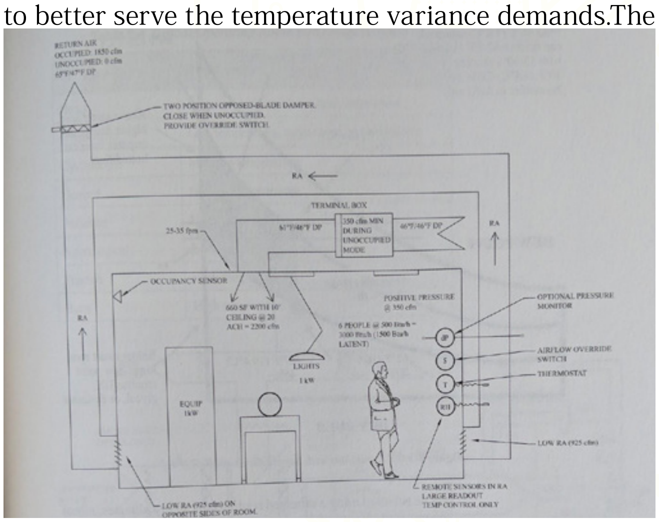


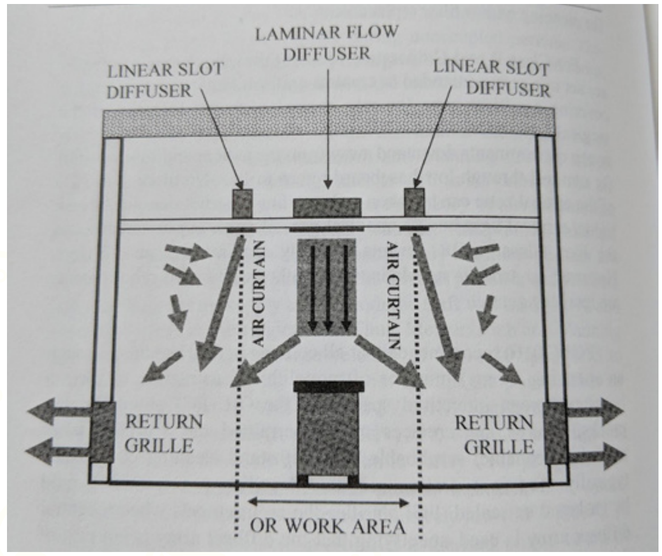
Figure 8-17 *Airborne Infectious Isolation (AII) Room Arrangement*

3.5.1.2 Critical Care Spaces

The air flow path for the critical spaces is the same as inpatient spaces, however, OR locations will be supplied by a venturi valve. The image below shows a typical operating room. The unit above the ceiling for the OR's in this facility will have a DX booster coil to better serve the temperature variance demands.The



airflow design of operating rooms focuses on infection control. The image on the right shows an air curtain created by a laminar flow diffuser above the patient and slot diffusers along the sides to create a bubble around the patient and provide only clean, filtered air to the surgical area. This allows doctors to freely move in and out of the air curtain and still minimize the risk of infection from anything airborne. The air handling unit serving these spaces (and all spaces in the facility) have high pre- and post-filters, rather than a filter at the room supply diffuser. This simplifies the maintenance process, as in-room filter changes require heavy sanitation procedures to prepare the room for upcoming surgeries, resulting in care for fewer people.



3.5.1.3 Service Spaces

The main service spaces in the building are kitchen and laundry facilities, both of which are supplied by air handling units that process a portion of return air. The air is distributed from the air handling unit with the minimum specified outside air and return air mixture that has been filtered and conditioned for the space. The air is then supplied to the space, and eventually returned to the unit to be relieved or returned and filtered. In the kitchen spaces, much of this air will be exhausted, per code based design.

3.5.1.4 Common Area Spaces

The air flow path for the common area spaces is the same as non-kitchen service spaces. This includes waiting areas, office areas, and circulation areas.

3.5.2 Ventilation Requirements

The varying levels of infection control directly impact the need for differing amounts of outdoor air. Several space types are served by 100% filtered outside air and exhaust 100% of the air supplied to maintain microbial control of the space. These spaces are served by designated air handling units that only process 100% outside air. Other spaces are served by an amount of outside air as deemed by ASHRAE 62.1 and refilter and recycle the return air from these spaces. Refer to page 61 for Outside Air Calculations.

3.5.3 Relief and Toilet Exhaust

To keep the roof clean on both the upper and lower level, all exhaust, relief, and outside air fans will be in the mechanical penthouse. Components on the roof will be limited to plumbing vents and air louvers. The provided relief duct system will consist of a relief fan system in the penthouse (with VFD), un-insulated galvanized sheet metal relief duct riser and takeoffs on each floor. Take-offs shall have fire/smoke dampers, two position dampers, and manual balancing dampers. A static pressure sensor in the duct shall adjust the VFD to maintain the setpoint. Discharge through the upper roof shall be louvered. A toilet exhaust system shall be provided for each level. The toilet exhaust fan on the roof shall discharge through louvers. The design excludes energy recovery due to the potential risk of microbial dispersion. The air distribution system will be providing the cleanest air possible by interspersing the air streams.

3.5.4 Venturi Valves

Venturi valves will control the pressure in the highly sensitive spaces in the facility, such as the ORs. They are immune to lint and dust in the airstream that can clog VAVs and disrupt the supply and exhaust balance. They also require minimal maintenance, resulting in fewer disruptions in usage.

Each unit that serves an OR will be equipped with a DX booster coil with a stand-alone condenser. This allows for more rapid temperature changes to quickly prepare the room for use. With a rapid environmental adjustment, less energy is required to keep the space prepped for extended hours.

3.5.5 Vibration Isolation

Major floor mounted equipment on levels other than Lower Level 5 will be equipped with springs to control vibration. If site testing shows that additional isolation is necessary, self-leveling systems may be implemented.

3.5.6 Acoustic Control

The major mechanical equipment in the hospital is located far from patient rooms and procedure rooms to minimize disruption of patient and staff activities. Main duct runs will be located above coordinators whenever possible to prevent excess noise in these areas. Sound attenuators will be placed within the ductwork at identified problem areas. Acoustic control is important to Murex's design because hospitals designed and constructed with reduced noise levels typically experience higher patient satisfaction due to the more comforting environment and improved sleep. These factors can lead to quicker healing times, which can mean shorter stays and reduced costs for both patients and hospitals. From a hospital employee perspective, a low-noise environment can increase job satisfaction, which could reduce employee turnover. All of these components influence the patient experience for which Murex is designing.

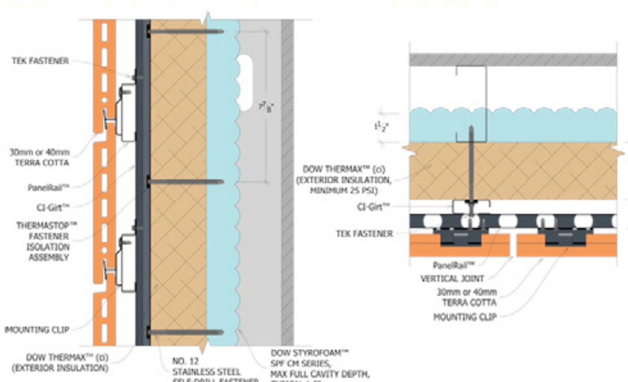
3.6.0 Enclosure

3.6.1 Vertical Exterior Facade

The mechanical team worked with the architect and the structural team to select the TERRART®-Large Terracotta Facade. The rear-ventilated facade allows for air movement (via the chimney effect) within the wall to optimize the energy efficiency of the mechanical system. The facade protects against extreme temperatures to maintain room conditions.

Item	Component	Thickness
1	Interior Finish *(vapor permeable)*	0"
2	Interior Gypsum Board	5/8"
3	Metal Stud *(18 GA. Min. @16" O.C.)*	6"
3A[2]	Stud Cavity Insulation *(Optional)*	2"
4[1]	Exterior Gypsum Sheathing	5/8"
5[2]	Self-Adhered Air/Water/Vapor Barrier	40mils
6[2]	Continuous Insulation	2 1/2"
7	Cladding Attachment System	1 1/2"
8[2]	Double Wall Terra-Cotta Cladding	1 1/2"
	Total	**12 3/4"**

The wall construction is made of the materials listed on the chart above. The design U-Factor is 0.064, and the design R-Factor is R-13 + R-7.5 (stud cavity insulation addition). The wall assembly meets energy code and project thermal requirements without the stud cavity insulation, but for this project, the team specified the additional insulation.



The construction of the facade provides a gas utility savings of over 23% in comparison to a simple concrete facade construction. It provides a total building energy savings of 5% according to calculations performed in Trane Trace 700.

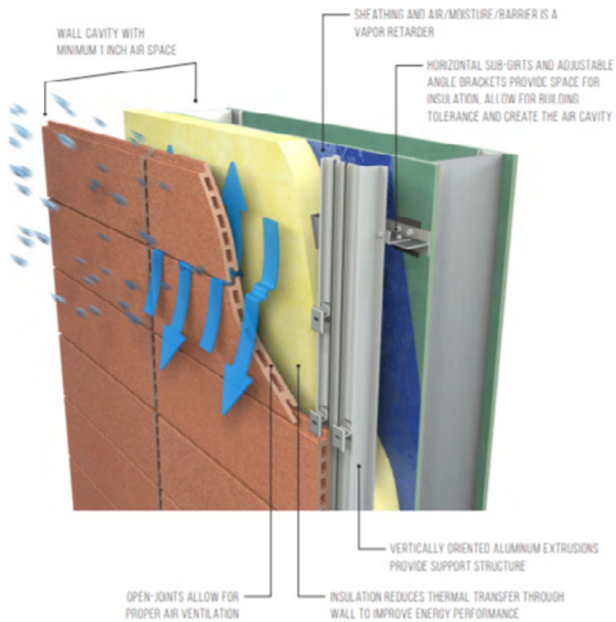
The energy consumption by the Children's Hospital and Medical Center is about 65% better than the baseline typical hospital energy use in Climate Zone 5A (per ASHRAE) according to the NREL 2010 Edition. It is also about 28% better than the low-energy typical hospital baseline.

3.6.1.1 Removal of Thermal Bridge

The facade has maximum insulation by eliminating the thermal bridge. The removal of the thermal bridge and addition of the chimney effect prevent mist and mold development that may otherwise occur.

3.6.1.2 Thermal Shield

The facade also maximizes on a thermal shield to protect the building from solar rays and extreme temperature. The design allows for air to flow through open joints to balance air pressure and minimize water penetration. Back ventilation assists in maintaining a dry cavity and negates the build-up of hot air. As a result,



the perimeter walls change temperature at a slower rate

3.6.1.3 Resulting Comfort

The proposed facade creates energy savings due to the lowered envelope load. The ventilated facade also promotes the health of safety of every occupant by maintaining thermal and hygrometric balance.

3.6.2 Roof Enclosure

In cohesion with the structural team's design, equipment was placed to benefit all disciples. A lot of coordination occurred to ensure the mechanical equipment operates correctly while having the required clearance. Refer to mechanical sheet 68 for the penthouse layout. The central plant equipment is placed on a lower level to reduce the stress on the supporting members. The cooling tower will be placed on the lower roof of the facility. This roof level will also house an outdoor garden seating area for patients to enjoy the outdoors. The cooling tower will be shielded by a vertical garden and be utilized as a focal feature.

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This option was chosen over ground mounted options due to the congested existing campus and future project plans (i.e. the neighboring parking garage). This location is also at a higher elevation than the chillers so the pump will work correctly, and it ensures free area around the cooling tower for proper operation and maintenance. All pumps needed in the roof enclosure are placed in a pump room so proper maintenance can be performed easily. The equipment has been placed so that all duct, pipe, and fittings can fit between the structure and to minimize penetrations in the voided slab.

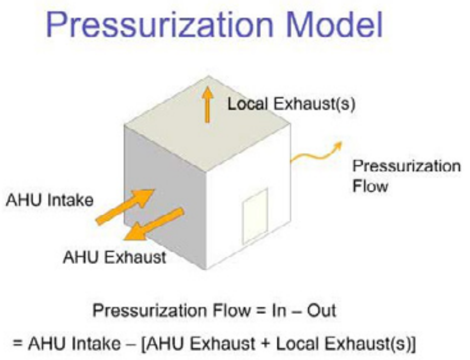
3.6.3 Clean Roof

The cooling tower will be the only equipment placed on either roof in attempts to meet the clean roof design. The lower rooftop garden deviates from the typical "clean roof" concept, but it creates an outdoor feature that the hospital's campus would not otherwise be able to house, due to the continuous development. This was a design decision weighed by the influence of greenery and outdoor exposure for health and happiness and the value of land for real estate purposes and its role in facility growth.

3.7.0 Pressurization

3.7.1 Building Pressurization

Building pressurization is designed to be slightly positive to ensure there is no infiltration. It is imperative to maintain building pressure because infiltration significantly affects not only building loads, but also infection control. Building pressurization is controlled by pressure gauges reading the interior and exterior pressure. The pressure sensors communicate with the building relief fan, and the fan modulates by use of a VFD to maintain the correct pressure. The design calls for a total of 187,850 CFM of outside air, 51,445 CFM of exhaust air, and 136,400 CFM of exfiltration. The calculations can be seen on page 59. These values are calculated to meet the recommendations of the IMC. The relief duct pathway is designed to support 162,130 CFM to allow for future expansion in the facility as shell space is finished out. The building is designed with exfiltration to ensure it will have a positive pressure. System air balance between outdoor air, relief air, and



System air balance between outdoor air, relief air, and toilet exhaust will allow approximately 3.5% of the design CFM for positive pressure. It is imperative that the specialized medical use spaces maintain a positive pressure for infection control and the safety of the occupants.

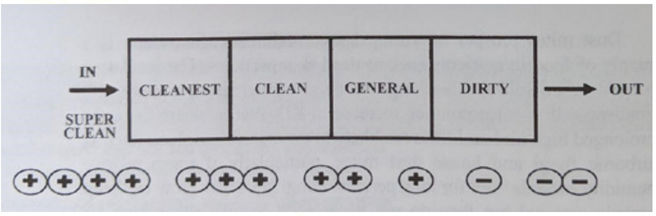
3.7.2 Stair Pressurization

Stair pressurization is designed to ensure proper pressure is maintained in the stairway in the case of an emergency or fire so that smoke will not enter the path of egress. Stair pressurization shafts are located directly behind the stairwells. In the case of an event the stair pressurization fan will turn on and the stairway will become pressurized. The stair pressurization fan is selected so the pressure differential will still allow the door to operate correctly.

3.7.3 Specific Spaces

According to Table 7 of ASHRAE Standard 170, the design parameters for hospital spaces widely vary.

Below is a diagram of pressurization airflow for infection control purposes. The following sections will be addressing specific areas based on this information.



3.7.3.1 Inpatient Spaces

Simple patient rooms do not have specified pressurizations, however any protective environment rooms that require anterooms must have positive pressures to keep any potential contaminants from the rest of the building population. To provide the hospital flexibility, all patient rooms were designed to potentially be a critical care room to accommodate overflow if necessary. Therefore, they were all designed with a positive pressurization.

3.7.3.2 Critical Care Spaces

The majority of spaces covered under critical care require positive pressurization to maintain sterilization. These space types include operating rooms, the intensive care units, the delivery rooms, trauma care rooms, and procedure rooms. The majority of the patient rooms on our levels fall into these categories. Pressure requirements for these spaces shall be maintained in the event of loss of normal electrical power. This conforms with the provisions of NFPA 99, Standard for Health Care Facilities 5 (Refer to Section 4.4 of NFPA 99 for a specific list of equipment that should be on the essential electrical system).

3.7.3.3 Service Spaces

The main service spaces for the hospital are the kitchen and laundry areas. Any area that deals with trash, soiled linens, and other used items must be a negative space. Alternatively, spaces with clean linens must have positive spaces. Food preparation spaces do not have explicit pressurization requirements but must be appropriately exhausted.

3.7.3.2 Common Area Spaces

To assure the necessary pressurization for the spaces above is correct, the majority of the surrounding spaces have either negative requirements or no requirements all. This includes corridors and waiting rooms.

3.8.0 Plumbing Design

Murex focused on an overarching goal of maximum safety for the occupants of Children's Hospital and Medical Center. The plumbing design prioritizes that goal as well as Murex's other two goals of sustainability and integrity. As noted in each section, this design followed code and industry best practice throughout the process. All plumbing will be designed to meet the minimum requirements of 2015 Omaha Plumbing Code. Stack locations were coordinated with the structural team, to determine the best locations to penetrate the voided slab of each floor.

3.8.1 Domestic Water Service

Demand for the domestic water service was deterDemand for the domestic water service was determined by adding the fixture units for the fixtures served and then converting the quantity of fixture units to GPM per 2012 IPC. For the scope of this project, the domestic water pressure was estimated by considering the head loss of the building as a whole. It was determined that a booster pump will be required to maintain the water pressure throughout the entire building. Patient care buildings shall have a minimum of two separate service entrances designed for full demand. These services will enter the building at separate locations with a piped loop around the building. This provides uninterrupted water supply for operations and maintenance capability. Installation shall comply with 2015 Omaha Plumbing Code.

3.8.2 Sanitary Drainage

For the scope of this project, only the system main has For the scope of this project, only the system main has been sized. Demand for the sanitary drainage system was figured in accordance with 2012 IPC. The main was determined by summing the drainage fixture units for all of the fixtures in Children's Hospital and Medical Center and using the total for horizontal branch length. This calculation accounts for future expansion into the shell spaces and is shown in Table 62. Waste vent sizing follows this method.

3.8.3 Natural Gas

Demand for the natural gas service was determined by summing all of the equipment loads in MBH and then using the peak demand load and the estimated length of the total layout per 2012 IFGC. Table in Page 62 details this calculation. The natural gas will be supplied to the building at elevated pressure. There will be a pressure regulator on the supply to the kitchen equipment to bring the supply pressure down to meet the equipments' demand.

3.8.4 Hot Water Heaters

For the scope of this project, only the domestic hot water heating system and main have been sized.There are two hot water heating systems with two boilers each. The kitchen and sterilization areas will have their own separate system due to higher demand temperatures. Each system will have a storage tank that maintains the temperature of the water preventing the delay in the supply hot water to the fixtures. To calculate the main supply, the fixture units for the hot water demand are summed and converted to GPM per 2012 IPC. For the boilers, the fixture demand was converted into GPH. Using the estimated quantity of peak demand hours, the boilers are sized in 62. Each of the two systems is designed with two boilers that can carry approximately two-thirds of the peak demand load. This design will provide redundancy for each system to ensure there will be enough hot water for most of each day.

3.8.5 Roof Drainage

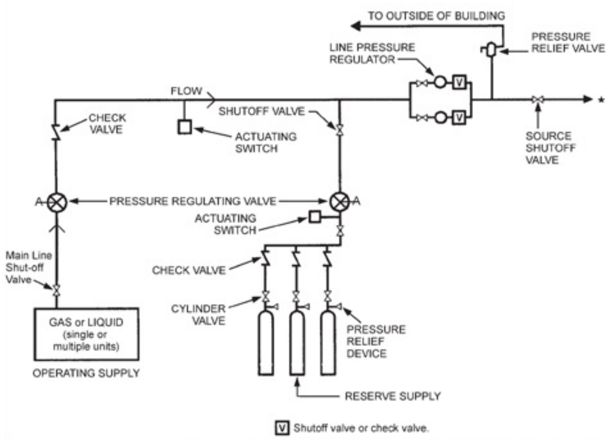
Roof drainage provided in accordance to the 2012 IPC chapter 11 and 2015 Omaha Plumbing Code. Overflow protection is to be provided by a backup system of roof drains. The overflow roof drain is placed 3" higher, therefore it will not operate unless the primary system fails. Adjacent wall run off was considered for this calculation, as seen in Table (Pg 62). Figure in (Pg 62) shows the roof drain zones.

3.8.6 Fire Protection

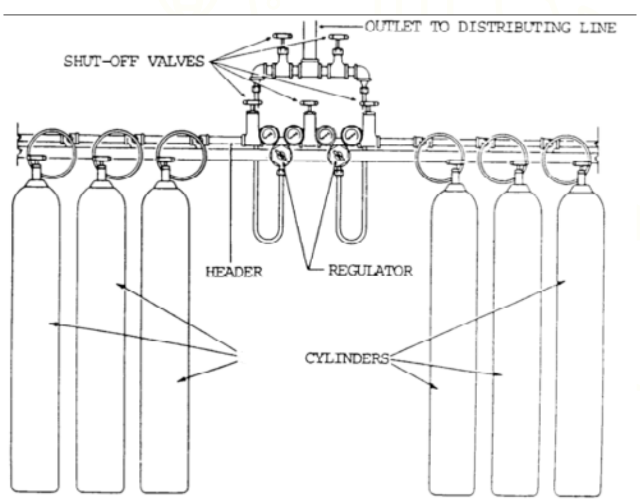
An Automatic sprinkler system is to be installed in accordance with 2012 IFP. The Omaha Children's Hospital and Medical Center is a light hazard building, with a commercial sized kitchen that is an ordinary hazard, therefore the fire protection system will be sized for ordinary hazard. Each sprinkler can cover a 15' x 15' area with a maximum center to center spacing of 15' - 0". For the scope of this project only the service entrance size has been calculated. Table in (Pg 62) shows this calculation.

3.8.7 Medical Gas

Medical gas is to be installed and stored in accordance with 2012 IPC and NFPA 99 and follow design guidelines described in FGI 2014. The patient rooms will be controlled in zones with shut off valves and control panels per floor. For the scope of this project only the system and required storage has been designed. Due to the size of this project, a bulk-oxygen system will be used. Table in (Pg 62) shows the calculation to estimate the monthly supply of oxygen and the required size of the bulk storage. This estimate includes assumed future expansion into the shell space.

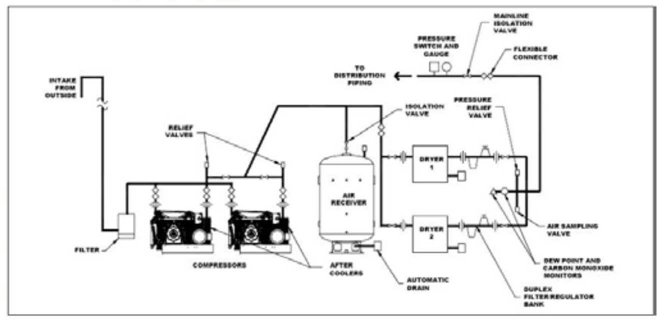


Nitrous oxide will only be supplied to anesthetizing locations from a cylinder-manifold system. The design will have a primary and reserve bank of K-cylinders for the typical monthly supply. To size the cylinder-manifold system, each anesthetizing location will require one-half cylinder for each primary and reserve monthly supplies; table in (Pg 62) depicts this calculation.



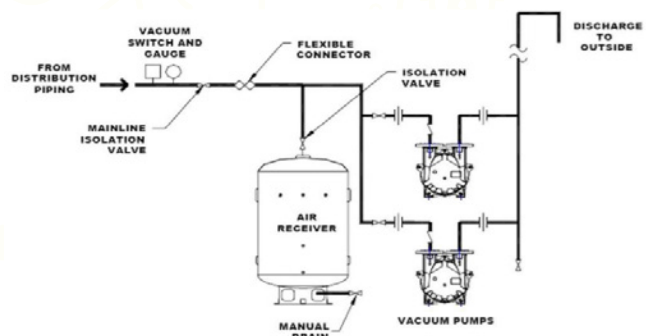
3.8.8 Compressed Medical Air

Medical air will be produced on site and supplied by a medical air-compressor system. This compressor system will consist of multiple compressors in sets. These sets will each have the capacity to supply the demand load and will run on a rotating schedule. This multiple redundancy design provides an uninterruptible supply of medical air. For the scope of this project only the required standard cubic feet per minute has been calculated. This calculation includes an estimated future expansion into the shell space. Table in (Pg 62) details this calculation.



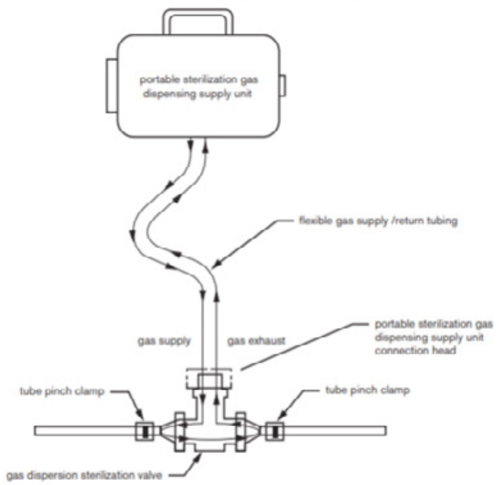
3.8.9 Vacuum

The vacuum system is to be installed in accordance with 2012 IPC and NFPA 99. Vacuum is produced by a dual vacuum pump for full redundancy with air exhausted from the system discharged directly to the atmosphere. For the scope of this project, only the required standard cubic feet per minute of the system has been calculated; table in (Pg 62) shows this calculation.



3.8.10 Sterilization

As there is no steam as part of the mechanical design, the facility will utilize a localized sterilization system using ozone gas. The facility manager or other staff can handle the system safely and monitor it. It is also environmentally friendly. It allows for 100% sterilization, rather than just disinfection and reduces the need for gamma radiation, eliminated degradation, and off-gassing of plastic components that could negatively affect the sterilization process. The image below shows the Portable Gas Transfer Devices and the connection required for the gas dispersion sterilization value to supply necessary spaces.



3.9.0 Controls & Building Monitoring System

The control system for the central plant will be a programmable logic control system (PLC). Every piece of equipment can be remotely controlled by facility personnel at any time, but the smart controls will interact with each other and the equipment VFDs t run at the most energy efficient setting at all times while maintaining code standards. While the Children's Hospital and Medical Center has the utmost faith in its facility management team, the advancement of building automation systems provide the best consistent results for the hospital's environment. As a medical facility, there is an expectation from patients and the community to utilize the latest technology in security and building management.

All units will have control sensors to be integrated with the building monitoring system. The system incorporated will be the DGLogik DGLux5 System as part of Acuity Brands. Through the BMS system, the facility managers and the owner will be able to track all of the equipment and maintain a record of the performance. This system allows for access to all data sources in a single unified workspace which can derive information from any database, iot device, or social media platform, among other things. It has an entirely drag and drop environment which allows for instant customization for which data sets are most important. The graphic below shows how the building monitoring system integrates with the mechanical system and the display portal it offers.

This will be shown at a kiosk in each lobby, as well as being the start screen for all TVs throughout the facility. In each patient room, the tv home screen will showcase the building monitoring system's live statistics and offer an interactive platform for patients and their families to explore. What will be shown in these public applications will be controlled from a centralized authoritative source within the hospital, as much information will be in this system that the public does not need access to, such as tracking of equipment and other patients, or security systems.

The patient rooms will all be individually controlled with smart thermostats for the patients. These controls will be integrated with the overall system for when hospital staff must override the system for patient safety.

3.10.0 Tornado Shelter and Refuge Design

To ensure the safety of the patients and staff during emergencies, the Murex team worked together to provide a tornado refuge across all levels in the structure. This section of the building includes a main stairway that leads to the basement tornado shelter. The stairwell will be pressurized, as described in the above sections, and air will be appropriately distributed to these spaces.

3.11.0 Conclusion

The design of the Omaha Children's Hospital and Medical Center was an opportunity to integrate design systems to provide a staple in the community. The Murex mechanical team carefully investigated design potentials to select the ideal combination of innovation, cost-justification, redundancy, and safety requirement to create the best possible solution for the facility. The design meets Murex's high caliber design standards for a long-lasting, reliable addition to the campus.

DESIGN PARAMETER

Omaha Children Hospital

Location	Omaha NE	
Dataset name	C:\Users\user\Desktop\Mechanical\Trace Jan 11\HOSPITAL JAN 10.TRC	
Calculation time	03:15 PM on 01/14/2018	
TRACE® 700 version	6.3.3	
Location	Omaha, Nebraska	
Latitude	41.0	deg
Longitude	95.0	deg
Time Zone	6	
Elevation	978	ft
Barometric pressure	28.8	in. Hg
Air density	0.0732	lb/cu ft
Air specific heat	0.2444	Btu/lb·°F
Density-specific heat product	1.0738	Btu/h·cfm·°F
Latent heat factor	4,726.8	Btu·min/h·cu ft
Enthalpy factor	4.3930	lb·min/hr·cu ft
Summer design dry bulb	90.9	°F
Summer design wet bulb	74.6	°F
Winter design dry bulb	-6.1	°F
Summer clearness number	0.95	
Winter clearness number	0.95	
Summer ground reflectance	0.20	
Winter ground reflectance	0.20	
Carbon Dioxide Level	400	ppm
Design simulation period	January - December	
Cooling load methodology	TETD-TA1	
Heating load methodology	UATD	

TRANE TRACE 700

CENTRAL PLANT DESIGN

System Checksums

System - 001 Single Zone

COOLING COIL PEAK — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 91 / 75 / 108
CLG SPACE PEAK — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	218,321	218,321	2	0	0
Glass Solar	1,567,655	0	1,567,655	12	1,978,549	26
Glass/Door Cond	166,254	0	166,254	1	21,952	0
Wall Cond	475,019	182,724	657,742	5	470,153	6
Partition/Door	347,284		347,284	3	355,169	5
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	187,938		187,938	1	64,369	1
Sub Total ==>	2,744,148	401,045	3,145,193	24	2,890,192	38
Internal Loads						
Lights	2,563,682	640,920	3,204,602	24	2,563,682	33
People	2,430,939	0	2,430,939	18	1,325,638	17
Misc	539,237	0	539,237	4	539,237	7
Sub Total ==>	5,533,858	640,920	6,174,778	47	4,428,556	58
Ceiling Load	294,016	-294,016	0	0	290,267	4
Ventilation Load	0	0	3,776,534	29	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	64,366		64,366	0	64,366	1
Exhaust Heat		-4,980	-4,980	0		
Sup. Fan Heat			2	0		
Ret. Fan Heat		2	2	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	8,636,389	742,971	13,155,896	100.00	7,673,383	100.00

HEATING COIL PEAK — Mo/Hr: Heating Design; OADB: -6

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-407,382	1.49
Glass Solar	0	0	0.00
Glass/Door Cond	-1,172,680	-1,172,680	4.30
Wall Cond	-795,262	-1,110,187	4.07
Partition/Door	-1,564,133	-1,564,133	5.74
Floor	-53,639	-53,639	0.20
Adjacent Floor	0	0	0
Infiltration	-338,128	-338,128	1.24
Sub Total ==>	-3,923,842	-4,646,150	17.04
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-232,978	0	0.00
Ventilation Load	0	-6,374,389	23.38
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-16,243,046	-16,243,046	59.59
Exhaust Heat		3,484	-0.01
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-20,399,866	-27,260,100	100.00

TEMPERATURES

	Cooling	Heating
SADB	52.6	124.2
Ra Plenum	74.1	70.6
Return	74.1	70.6
Ret/OA	77.6	54.6
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	364,694	364,694
Terminal	364,694	364,694
Main Fan	364,694	364,694
Sec Fan	0	0
Nom Vent	75,991	75,991
AHU Vent	75,991	75,991
Infil	3,964	3,964
MinStop/Rh	0	0
Return	290,961	290,961
Exhaust	2,258	2,258
Rm Exh	77,697	77,697
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	20.8	20.8
cfm/ft²	0.78	0.78
cfm/ton	332.65	
ft²/ton	428.22	
Btu/hr-ft²	28.02	-58.09
No. People	5,212	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	1,096.3	13,155.9	9,553.8	364,694	77.3	63.7	70.1	52.6	51.2	56.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1,096.3	13,155.9								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	469,470		
Part	51,623		
Int Door	0		
ExFlr	1,010		
Roof	42,600	0	0
Wall	139,657	29,636	21
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-27,273.5	364,694	54.6	124.2
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-27,273.5			

AIR TOTALS

Total Trace CFM	341490
Total Additional Required CFM	44320
TOTAL DESIGN CFM	385810
Total OA CFM	187805
Total Design CFM	385810
PERCENT OA	0.486781
Total OA CFM	187805
EXHAUST AIR	51445
TOTAL DESIGN CFM	239250

TRACE LOADS

RECIRC AIR / 100% OA

Designation	Cooling Loads: Load (Tons)	Cooling Loads: Cooling Coil Peak	Cooling Loads: Latent Peak	Cooling Loads: Sensible Peak	Heating Coil: Sensible Peak
AHU 001	106	1,274,822	712,985	561,837	1,676,327
AHU 002	51	612,060	334,937	277,123	472,346
AHU 003	95	1,136,302	590,461	545,841	682,430
AHU 004	46	552,836	230,023	322,813	385,775
AHU 005	19	222,999	84,269	138,730	224,318
AHU 006	12	143,958	76,990	66,968	142,783
AHU 007	44	530,903	302,915	227,988	492,395
AHU 008	96	1,147,252	502,028	645,224	844,887
AHU 009	11	135,297	42,944	92,353	151,460
AHU 010	15	174,505	92,298	82,207	152,851
AHU 011	55	660,751	274,034	386,717	438,663
AHU 012	24	282,777	56,306	226,471	359,652
AHU 013	10	121,338	47,763	73,575	128,035
AHU 014	66	786,858	307,131	479,727	676,757
AHU 015	4	43,689	25,021	18,668	40,139
AHU 016	17	199,560	45,329	154,231	171,889
AHU 017	26	307,107	98,153	208,954	336,213
AHU 018	21	253,632	75,957	177,675	206,803
AHU 019	33	398,778	170,853	227,925	228,770
AHU 020	7	81,113	37,016	44,097	55,046
AHU 021	26	312,281	68,402	243,879	310,594
AHU 022	15	180,809	29,835	150,974	156,700
AHU 023	111	1,330,479	506,324	824,155	1,431,516
AHU 024	23	276,794	55,167	221,627	305,506
FUTURE 001	44	531,646	169,557	362,089	465,502
FUTURE 002	30	356,724	153,578	203,146	287,107
FUTURE 003	52	625,256	294,267	330,989	703,850

COOLING CFM

RECIRC AIR / 100% OA

Designation	Delta T	Qs	CALCULATED CFM	SIZED CFM	Delta G	Ql	Qt
AHU 001	29.7	561,837	17200	20000	25.5	302634	864,471
AHU 002	55	277,123	4585	8000	46.3	146477	423,600
AHU 003	43	545,841	11540	15000	47	374242	920,083
AHU 004	23.9	322,813	12280	15000	13.6	115236	438,049
AHU 005	22.6	138,730	5585	8000	12.8	49327	188,057
AHU 006	37.4	66,968	1630	2000	53.7	60396	127,364
AHU 007	35	227,988	5925	8000	46	188060	416,048
AHU 008	24.9	645,224	23560	25000	15.1	245472	890,696
AHU 009	34.4	92,353	2445	5000	46.1	77773	170,126
AHU 010	37.8	82,207	1980	5000	47.9	65441	147,648
AHU 011	24	386,717	14650	18000	13	131411	518,128
AHU 012	19.3	226,471	10670	15000	24.9	183321	409,792
AHU 013	33.7	73,575	1985	5000	41.9	57388	130,963
AHU 014	23.1	479,727	18880	20000	11.8	153721	633,448
AHU 015	35	18,668	485	1000	46.2	15461	34,129
AHU 016	17.4	154,231	8060	10000	3.9	21689	175,920
AHU 017	35	208,954	5430	8000	51.8	194079	403,033
AHU 018	31.6	177,675	5115	8000	36.8	129880	307,555
AHU 019	23.4	227,925	8855	10000	13.6	83095	311,020
AHU 020	42.5	44,097	945	2000	60.8	39645	83,742
AHU 021	23.1	243,879	9600	15000	33	218592	462,471
AHU 022	29.7	150,974	4625	8000	36.1	115204	266,178
AHU 023	46	824,155	16290	18000	8.3	93293	917,448
AHU 024	22.4	221,627	8995	10000	32.3	200472	422,099
FUTURE 001	34.3	362,089	9600	15000	51	337824	699,913
FUTURE 002	36	203,146	5130	8000	58.7	207780	410,926
FUTURE 003	26.1	330,989	11530	15000	13.4	106606	437,595

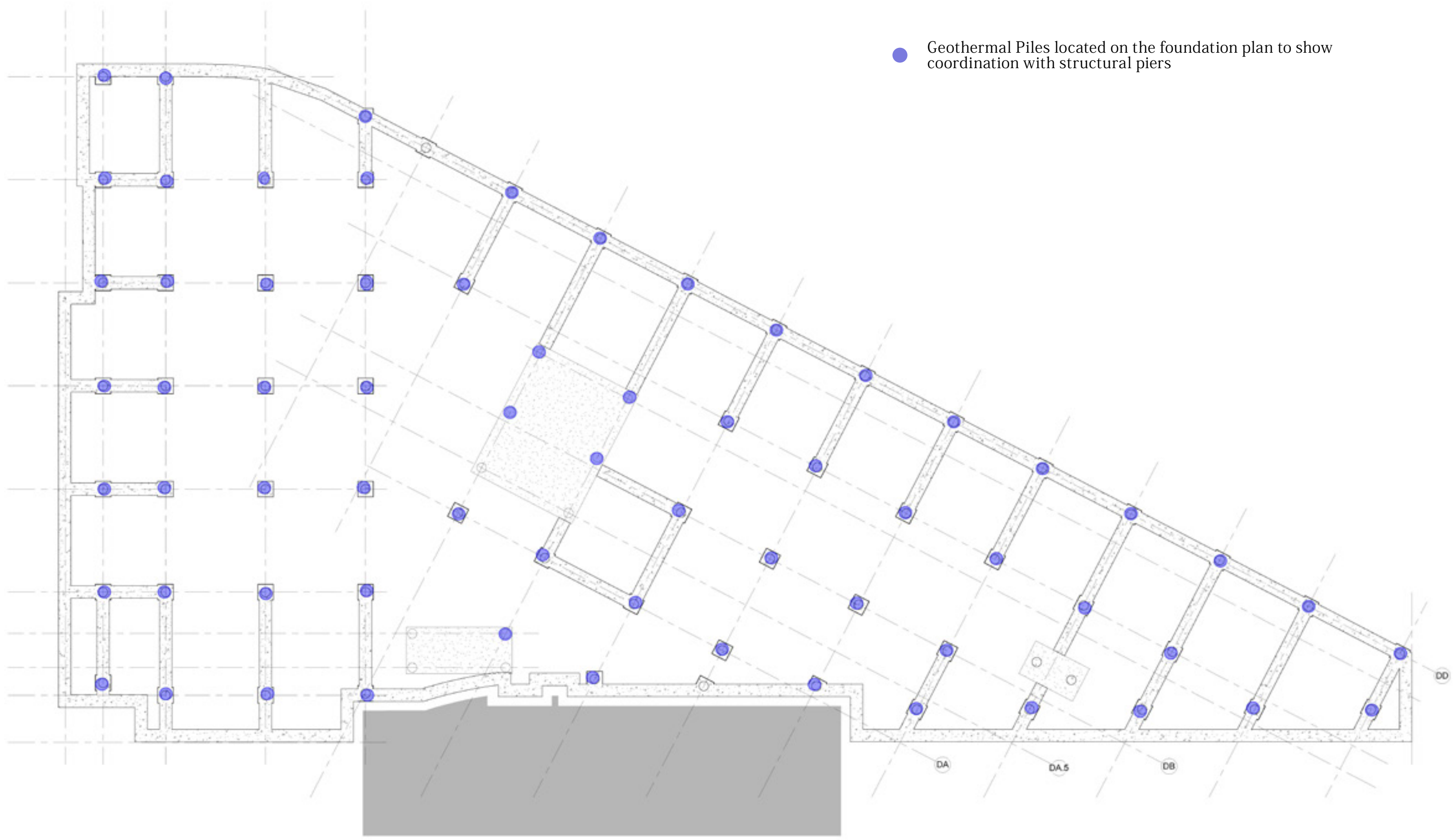
HEATING CFM

RECIRC AIR / 100% OA

Designation	Delta T	Qs	CALCULATED CFM	ASSIGNED CFM
AHU 001	124.5	1,676,327	12240	15,000
AHU 002	99.3	472,346	4324	5,000
AHU 003	94.7	682,430	6551	8,000
AHU 004	61.9	385,775	5666	8,000
AHU 005	71.2	224,318	2864	5,000
AHU 006	120.8	142,783	1075	2,000
AHU 007	107.4	492,395	4168	5,000
AHU 008	69.3	844,887	11083	15,000
AHU 009	122.1	151,460	1128	2,000
AHU 010	101.8	152,851	1365	2,000
AHU 011	64.2	438,663	6212	8,000
AHU 012	129.4	359,652	2527	5,000
AHU 013	136.3	128,035	854	2,000
AHU 014	77.8	676,757	7908	10,000
AHU 015	106.1	40,139	344	1,000
AHU 016	32.4	171,889	4823	8,000
AHU 017	115.6	336,213	2644	5,000
AHU 018	97.5	206,803	1928	5,000
AHU 019	54.4	228,770	3823	5,000
AHU 020	120.7	55,046	415	1,000
AHU 021	109.4	310,594	2581	5,000
AHU 022	96.7	156,700	1473	2,000
AHU 023	96.7	1,431,516	13458	15,000
AHU 024	110.7	305,506	2509	5,000
FUTURE 001	107.7	465,502	3929	5,000
FUTURE 002	94.6	287,107	2759	5,000
FUTURE 003	119.5	703,850	5355	8,000

EXHAUST AIR CALCULATION

Level	Area Type	Fixtures	Area	Exh CFM ACH	Exh CFM 2 CFM/SF	Exh CFM CFM/Fixture	Exh CFM Applied
LL5	Individual Toilet	1	100	150	200	50	200
LL3	Commercil Kitchen	0	8095	12145	16190	0	16190
LL3	Small Kitchen	0	296	445	592	0	595
LL3	Locker/Shower	1	55	85	110	20	110
LL3	Individual Toilet	3	300	450	600	150	600
LL3	Sleep Room Toilets	12	360	540	720	600	720
LL1	Womens's/Men's RR	4	275	415	550	280	550
LL1	Individual Toilets	13	1300	1950	2600	650	2600
LL1	Patient Room Toilet/Showers	6	180	270	360	210	360
LL1	Short Stay Room Toilet	14	180	270	360	700	700
L1	Individual Toilets	14	1400	2100	2800	700	2800
L1	Short Stay Room Toilet	7	210	315	420	350	420
L2	Individual Toilets	9	900	1350	1800	450	1800
L2	Womens's/Men's RR	4	275	415	550	280	550
L3	Individual Toilets	6	600	900	1200	300	1200
L3	Room Toilet/Showers	8	400	600	800	280	800
L4	Womens's/Men's RR	4	275	415	550	200	550
L4	Individual Toilets	4	400	600	800	200	800
L4	Room Toilet/Showers	68	3400	5100	6800	2380	6800
L5	Womens's/Men's RR	4	275	415	550	200	550
L5	Individual Toilets	4	200	300	400	200	400
L5	Room Toilet/Showers	64	3200	4800	6400	2240	6400
L6	Womens's/Men's RR	4	275	415	550	200	550
L6	Individual Toilets	6	600	900	1200	300	1200
L6	Room Toilet/Showers	40	2000	3000	4000	300	4000
					TOTAL EXHAUST		51445



Geothermal Piles located on the foundation plan to show coordination with structural piers

AHU SCHEDULE

AHU INFORMATION		
CFM:	See additional sheets	
Qs:		
Ql:		
Qt:		
Heating:	Hot water coil	
Cooling:	Chilled water coil	

LEVEL:	LL5	
Available room area:	10,000 SF	
Room height:	20' clear below structure	
For AHUs:	001	004
	002	005
	003	006

LEVEL:	LL1	
Available room area:	2,000 SF	
Room height:	14' clear below structure	
For AHUs:	007	010
	008	011
	009	

LEVEL:	L1	
Available room area:	2,000 SF	
Room height:	14' clear below structure	
For AHUs:	012	015
	013	016
	014	F001

LEVEL:	L7	
Available room area:	15,000 SF	
Room height:	16' clear below structure	
For AHUs:	017	021
	018	022
	019	023
	020	024
	F002	F003

DUAL RUN VERTICAL GROUND LOOP IN STRUCTURAL PIER

1 ton = ~200ft of linear pipe

89 ft piers

65 piers total

89ft/pier x 65 piers = 5785 total linear ft of pipe

5785 ft x 1 ton / 200 ft = ~ 30 tons

Assume dual run of pipe in each pier

2 x 30 tons = ~60 tons

Peak Cooling Load 1027 tons

Percentage of Building Load Provided
60 tons / 1027 tons = 5.5 %

SLINKY RUN GROUND LOOP IN STRUCTURAL PIER

Lp = use equation 1.2

Nl =	108.75	
Ll =	6.28	ft
d =	2	ft
P =	0.8	ft
Lt = (Nl * P) + d	89	ft

Lp = (108.75)x(6.28)+(108.75)x(2 x 0.8) + (2pi)/2 +2

Lp = 863 ft per slinky run

65 piers x 862 ft = 56030 total linear ft of pipe

56030 ton / 200ft/ton = 280.15 tons

Percentage of Building Load Provided
280.15 tons / 1027 tons = 27 %

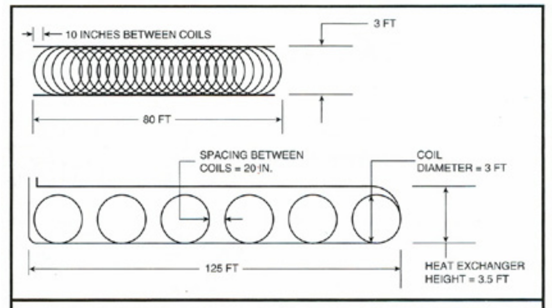


FIGURE 1.2: Multiple-Pipe Ground Heat Exchangers

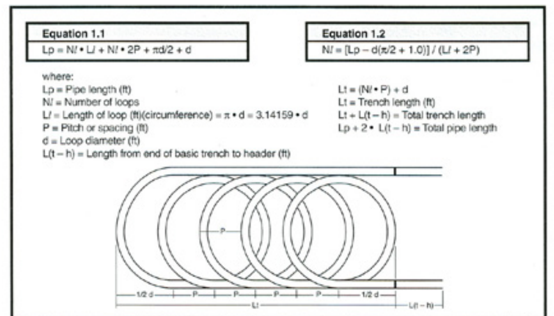


FIGURE 1.1: Nomenclature for Slinky Tables

EQUIPMENT SCHEDULE

COOLING TOWER

DESIG.	TYPE	CAPACITY (NOM. TONS)	GPM	EWT DEG. F	LWT DEG. F	DESIGN WB (DEG. F)	NUMBER OF CELLS	FAN HP	FAN SPEED CONTROL	EQUAL TO BASIS OF DESIGN MFR & MODEL #	ELECTRICAL VOLT/PH	ELECTRICAL HP
	MECHANICAL										ELECTRICAL	
CT-1	TOWER CELL	1109	2455	94.3	85	78	1	30	VFD	BAC SERIES 3000 XS3E-1222-14O	480/3	60

WATER COOLED CHILLER

DESIG.	CAP. (NOM. TONS)	REFRIDGERANT	EVAPORATOR GPM	EVAPORATOR EWT (°F)	EVAPORATOR LWT (°F)	EVAPORATOR WTR P.D. (FT)	CONDENSER GPM	CONDENSER EWT (°F)	CONDENSER LWT (°F)	CONDENSER WTR P.D. (FT)	EQUAL TO BASIS OF DESIGN MFR. & MODEL #	WEIGHT (LBS)	VOLT/PH	MCA	MOCP
	MECHANICAL												ELECTRICAL		
CH-1	825	R-134A	1644	54	42	14.6	2455	85	94.3	21.5	EVG	33497	460/3	743	1200
CH-2	825	R-134A	1644	54	42	14.6	2455	85	94.3	21.5	EVG	33497	460/3	743	1200

NATURAL GAS FIRED BOILER

DESIG.	TYPE	INPUT (MBH)	OUTPUT (MBH)	EFF. (%)	GPM	PRESSURE DROP (FT HEAD)	GAS PRESSURE (IN W.C.)	FLUE SIZE (IN.)	INTAKE SIZE (IN.)	EWT/LWT (°F)	BLOWER MOTOR HP	EQUAL TO BASIS OF DESIGN MFR. & MODEL #	WEIGHT	VOLT/PHASE
		MECHANICAL												ELECTRI
B-01	GAS	29,291.0	26,780.0	85.70%	5287	280	1	34	10	80/180	20	BURNHAM SERIES	97000	480/3
B-02	GAS	29,291.0	26,780.0	85.70%	5287	280	1	34	10	80/180	20	BURNHAM SERIES	97000	480/3

PUMP SCHEDULE

DESIG.	TYPE	DUTY	GPM	HEAD (FT)	EFF. (%)	MOTOR DATA HP	MOTOR DATA RPM	EQUAL TO BASIS	ACCESSORIES	VOLT/PH	HP
	MECHANICAL									ELECTRICAL	
BP-001, 002	SPLIT COUPLED VERTICAL	BOILER PUMP	2728	100	82.98%	100	1079	ARMSTR	A, B	480/3	100
CHP-001, 002	SPLIT COUPLED VERTICAL	CHILLER	1644	125	84.32%	75	1233	ARMSTR	A, B	480/3	75
CP-001	SPLIT COUPLED VERTICAL	CONSENSER	2450	60	76.02%	60	1161	ARMSTR	A, B	480/3	60

ACCESSORIES
A) PROVIDE
B) VFD WITH

CHILLED WATER & HOT WATER AIR HANDLING UNIT

MECHANICAL

DESIG.	SUPPLY FAN SECTION CFM	MIN OA CFM	ESP IN. W.G.	FAN TYPE	MOTOR HP	FLA	VOLT/PH	COOLING COIL TOTAL MBH	SENSIBLE MBH	EAT DB/WB	MAX. AIR VELOCITY (FPM)	MAX. AIR P.D. (IN. W.G.)	GPM	EWT/LWT (DEG. F)	WATER P.D. (FT)
AHU-001	20,000	6,860	3.00	SWSI	40.0	46.3	480/3	864.7	554.6	80.00/67.00	546	0.68	143.4	42.00/54.0	14.7
AHU-002	8,000	8,000	3.00	SWSI	15.0	17.7	480/3	437.9	270.1	80.00/67.00	476	1.42	73.2	42.00/53.9	3.5
AHU-003	15,000	4,210	3.00	SWSI	30.0	34.7	480/3	870.4	539.5	80.00/67.00	545	1.74	143.7	42.00/54.0	11.5
AHU-004	15,000	3,085	3.00	SWSI	25.0	29.4	480/3	459.5	309.0	80.00/67.00	485	0.26	76.4	42.00/53.9	12.6
AHU-005	8,000	2,895	3.00	SWSI	10.0	12.5	480/3	200.8	134.5	80.00/67.00	503	0.32	33.5	42.00/53.9	11.9
AHU-006	2,000	2,000	3.00	SWSI	5.0	6.1	480/3	118.2	71.6	80.00/67.00	476	1.70	19.6	42.00/54.0	9.2
AHU-007	8,000	8,000	3.00	SWSI	15.0	18.6	480/3	425.6	262.9	80.00/67.00	500	1.03	70.5	42.00/54.0	12.6
AHU-008	25,000	5,435	3.00	SWSI	30.0	36.0	480/3	896.5	574.2	80.00/67.00	518	0.40	149.8	42.00/53.9	17.5
AHU-009	5,000	5,000	3.00	SWSI	7.5	8.7	480/3	170.0	113.3	80.00/67.00	490	0.37	28.3	42.00/53.9	5.8
AHU-010	5,000	5,000	3.00	SWSI	7.5	8.7	480/3	148..20	101.5	80.00/67.00	490	0.32	24.5	42.00/54.0	4.6
AHU-011	18,000	9,925	3.00	SWSI	20.0	24.0	480/3	547.0	371.6	80.00/67.00	458	0.26	90.6	42.00/54.0	7.5
AHU-012	15,000	15,000	3.00	SWSI	20.0	24.0	480/3	430.8	291.0	80.00/67.00	502	0.27	71.8	42.00/53.9	17
AHU-013	5,000	5,000	3.00	SWSI	7.5	8.7	480/3	136.6	95.9	80.00/67.00	490	0.28	22.6	42.00/54.0	4.1
AHU-014	20,000	5,825	3.00	SWSI	25.0	30.3	480/3	666.2	439.1	80.00/67.00	508	0.36	110.3	42.00/54.0	10
AHU-015	1,000	1,000	3.00	SWSI	25.0	30.3	480/3	34.2	22.3	80.00/67.00	455	0.57	5.7	42.00/54.0	5.8
AHU-016	10,000	1,260	3.00	SWSI	15.0	17.3	480/3	179.5	129.3	80.00/67.00	485	0.18	29.6	42.00/54.0	9.6
AHU-017	8,000	8,000	3.00	SWSI	15.0	17.3	480/3	409.9	255.8	80.00/67.00	476	0.86	67.9	42.00/54.0	7.8
AHU-018	8,000	8,000	3.00	SWSI	10.0	11.6	480/3	318.3	205.5	80.00/67.00	476	0.49	53.1	42.00/53.9	18.3
AHU-019	10,000	11,655	3.00	SWSI	15.0	17.3	480/3	329.1	218.4	80.00/67.00	485	0.31	54.9	42.00/53.9	14.1
AHU-020	2,000	2,000	3.00	SWSI	5.0	5.9	480/3	84.2	54.7	80.00/67.00	476	0.68	13.9	42.00/54.0	5.1
AHU-021	15,000	15,000	3.00	SWSI	20.0	24.7	480/3	484.9	314.2	80.00/67.00	500	0.32	80.1	42.00/54.0	18.8
AHU-022	8,000	8,000	3.00	SWSI	10.0	12.2	480/3	273.9	181.8	80.00/67.00	476	0.32	45.6	42.00/53.9	10.9
AHU-023	18,000	9,030	3.00	SWSI	25.0	29.5	480/3	928.8	578.6	80.00/67.00	458	0.84	154.7	42.00/54.0	17.9
AHU-024	10,000	10,000	3.00	SWSI	15.0	17.9	480/3	422.1	267.60	80.00/67.00	485	0.61	69.7	42.00/54.0	13.6

DESIG.	PRE-HEAT COIL MBH	EAT	LAT	MAX. AIR P.D. (IN. W.G.)	GPM	EWT/LWT (DEG F)	WATER P.D. (FT)
AHU-001	1716.0	50.00	129.94	0.27	175.5	180.00/15	4.0
AHU-002	486.9	50.00	140.80	0.09	49.9	180.00/15	3.9
AHU-003	694.3	50.00	130.84	0.13	71.5	180.00/16	1.7
AHU-004	390.6	50.00	95.42	0.02	40.2	180.00/16	1.4
AHU-005	238.5	50.00	94.40	0.02	24.4	180.00/15	7.9
AHU-006	145.3	50.00	117.69	0.13	15.0	180.00/16	12.3
AHU-007	516.4	50.00	110.11	0.12	52.8	180.00/15	14.0
AHU-008	932.7	50.00	107.95	0.08	95.8	180.00/16	4.4
AHU-009	153.7	50.00	78.64	0.08	15.8	180.00/15	1.5
AHU-010	168.0	50.00	81.30	0.09	17.2	180.00/15	1.8
AHU-011	551.6	50.00	78.57	0.03	56.6	180.00/15	3.3
AHU-012	372.2	50.00	73.11	0.07	38.2	180.00/16	3.7
AHU-013	161.8	50.00	80.16	0.08	16.7	180.00/16	7.3
AHU-014	691.2	50.00	114.46	0.15	70.8	180.00/15	5.7
AHU-015	55.2	50.00	101.46	0.09	5.7	180.00/15	0.3
AHU-016	270.9	50.00	81.54	0.02	27.8	180.00/15	9.7
AHU-017	348.7	50.00	115.02	0.04	35.8	180.00/15	4.4
AHU-018	222.3	50.00	91.45	0.02	22.9	180.00/16	7.3
AHU-019	234.3	50.00	93.75	0.01	24.2	180.00/16	7.4
AHU-020	60.9	50.00	78.35	0.04	6.2	180.00/15	0.3
AHU-021	325.3	50.00	110.68	0.01	33.3	180.00/15	14.6
AHU-022	157.8	50.00	123.39	0.04	16.3	180.00/16	3.8
AHU-023	1474.1	50.00	141.56	0.14	151.4	180.00/16	17.1
AHU-024	312.6	50.00	108.35	0.02	32.0	180.00/15	12.7

DESIG.	RE-HEAT COIL MBH	EAT	LAT	MAX. AIR P.D. (IN. W.G.)	GPM	EWT/LWT (DEG F)	WATER P.D. (FT)	PRE-FILTER 1 TYPE	PRE-FILTER 1 MERV	FINAL FILTER TYPE	FINAL FILTER MERV	EQUAL TO BASIS OF DESIGN MFR. & MODEL	ACCESSORIES (SEE BELOW)	WEIGHT (LBS)
AHU-001	1747.8	52.00	133.70	0.27	179.7	180.00/160.03	4.1	ANGLE	8	RIGID	14	YORK	B, C, D, E, F, H,	6995
AHU-002	465.1	52.00	106.30	0.10	47.8	180.00/160.02	7.7	ANGLE	8	RIGID	14	YORK	B, C, D, E, F	4379
AHU-003	703.2	52.00	134.16	0.06	72.3	180.00/160.02	9.2	ANGLE	8	RIGID	14	YORK	B, C, D, E, F, H,	6299
AHU-004	430.4	52.00	78.82	0.04	44.3	180.00/160.07	10.6	ANGLE	8	RIGID	14	YORK	B, C, D, E, F, H,	5182
AHU-005	238.6	52.00	96.58	0.02	24.5	180.00/160.01	1.3	ANGLE	8	RIGID	14	YORK	B, C, D, E, F, H,	3942
AHU-006	142.5	52.00	118.62	0.12	14.7	180.00/160.03	11.8	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	2183
AHU-007	511.7	52.00	147.59	0.10	52.7	180.00/160.05	5.9	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	4030
AHU-008	888.2	52.00	85.23	0.05	91.6	180.00/160.07	7.5	ANGLE	8	RIGID	14	YORK	A, C, D, E, F, H,	4985
AHU-009	158.8	52.00	81.69	0.08	16.3	180.00/160.03	7.1	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	2804
AHU-010	150.3	52.00	80.11	0.04	15.5	180.00/160.04	4.7	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	2805
AHU-011	541.5	52.00	80.15	0.03	55.7	180.00/160.02	3.2	ANGLE	8	RIGID	14	YORK	A, C, D, E, F, H,	6339
AHU-012	422.4	52.00	78.32	0.04	43.5	180.00/160.06	15.4	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	5666
AHU-013	134.0	52.00	77.07	0.04	13.7	180.00/159.94	3.7	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	2795
AHU-014	712.2	52.00	85.29	0.05	73.5	180.00/160.09	5.0	ANGLE	8	RIGID	14	YORK	A, C, D, E, F, H,	8037
AHU-015	40.2	52.00	89.63	0.07	4.1	180.00/159.98	0.1	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	2840
AHU-016	298.0	52.00	79.85	0.04	30.7	180.00/160.07	11.7	ANGLE	8	RIGID	14	YORK	A, C, D, E, F, H,	4280
AHU-017	342.1	52.00	116.01	0.04	35.2	180.00/160.02	4.2	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	4080
AHU-018	217.9	52.00	92.78	0.02	22.4	180.00/159.97	6.9	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	3828
AHU-019	298.0	52.00	79.85	0.04	30.7	180.00/160.07	11.7	ANGLE	8	RIGID	14	YORK	A, C, D, E, F, H,	4342
AHU-020	55.1	52.00	103.49	0.02	5.7	180.00/160.02	0.2	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	2095
AHU-021	319.2	52.00	111.74	0.01	32.7	180.00/159.93	14.0	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	4922
AHU-022	164.5	52.00	128.77	0.04	16.8	180.00/159.94	4.0	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	3885
AHU-023	1446.8	52.00	142.17	0.14	148.6	180.00/160.00	16.5	ANGLE	8	RIGID	14	YORK	A, C, D, E, F, H,	6744
AHU-024	306.7	52.00	109.44	0.02	31.4	180.00/159.91	12.2	ANGLE	8	RIGID	14	YORK	A, C, D, E, F	4593

ACCESSORIES
(A) - DIRECT
(B) - BELT
(C) - FAN
(D) - VFD
(E) - FILTER
(F) - STEAM
(G) - UV FILTER
(H) - AIR BLENDER
(I) - ECONOMIZER

Energy Comparsion Calculation

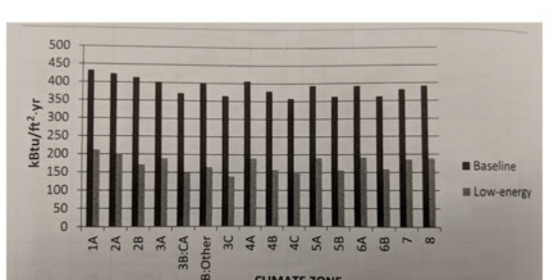
	Total Source Energy	Total Building Energy	Electric Consumption	Gas Consumption
TERRART Facade	134172448	48862418	12448735	6381711
Simple Constrcution Facade	136671488	50944661	12492949	8306226
Percent Better	1.83%	4.09%	0.35%	23.17%

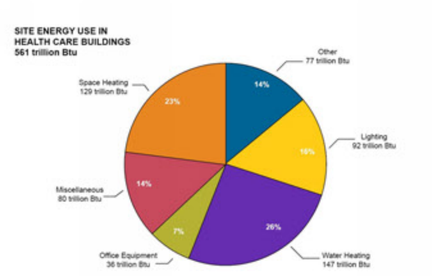
***The Trane Trace calculations for energy consumption did not include all aspects of hospital energy usuage. The areas accounted for are lighting, office equipment, space heating, and a mixture of miscellaneous loads. To account for the other loads, the pi graph below was used.

Accounts for ~ 60%

Total Enery Loads Coparison for Climate 5A

	Omaga CHMC Facility	Baseline	Low Energy
Energy Load	68407385.2	200000000	95000000
Percent Better	-----	65.80%	27.99%





OUTSIDE AIR CALCULATION

AHU	Level	Area Type	Area (Az)	Rate (Ra)	People (Pz) /1000	People (Pz) Density	Rate (Rp)	RaAz	RpRz	Code Required Ventilation OA (Vbz)	Applied Ventilation OA	Trace CFM	Trace CFM2	Min CFM A*0.65	SA CFM	Change in CFM3
001	LL5	Mechanical	30951	0.12	0	0	0	3714.1	0.0	3715	3715	14455	14455	20120	20120	**5665**
001	LL5	Storage	7768	0.12	0	0	0	932.2	0.0	935	935	4569	4570	5050	5050	**485**
001	LL5	Work Spaces	3203	0.06	5	17	5	192.2	85.0	280	280	1535	1535	2085	2085	**550**
001	LL5	Central Location	6203	0.06	50	311	5	372.2	1555.0	1930	1930	9296	9300	4035	9300	**5**
002	LL3	Cleaning	8444	0.12	10	85	25	1013.3	2125.0	3140	8475	8471	8475	5490	8475	**5**
002	LL3	Storage & Linen	2498	0.12	10	25	25	299.8	625.0	925	1625	978	980	1625	1625	**650**
002	LL5	Pharmacy	8002	0.18	10	81	5	1440.4	405.0	1850	5415	5413	5415	5205	5415	**5**
003	LL3	Exterior Kitchen	8100	0	0	0	0	0.0	0.0	0	0	6190	6190	5265	6190	**0**
003	LL3	Interior Kitchen	324	0	0	0	0	0.0	0.0	0	0	223	225	215	225	**5**
003	LL3	Exterior Corridor	5289	0.06	0	0	0	317.3	0.0	320	320	4056	4060	3440	4060	**5**
003	LL3	Exterior Dining	2095	0.18	70	147	7.5	377.1	1102.5	1480	1480	3500	3500	1365	3500	**0**
003	LL3	Interior Dining	3407	0.18	70	239	7.5	613.3	1792.5	2410	2410	3170	3170	2215	3170	**0**
004	LL3	Exterior Sleep Rooms	893	0	10	9	25	0.0	225.0	225	225	829	830	585	830	**5**
004	LL3	Interior Sleep Rooms	1290	0	10	13	25	0.0	325.0	325	325	463	465	840	840	**380**
004	LL3	Office Area	5726	0.06	5	29	5	343.6	145.0	490	490	4849	4850	3725	4850	**5**
004	LL3	Conference	1100	0.06	50	55	5	66.0	275.0	345	345	1323	1325	715	1325	**5**
004	LL3	Interior Multi-use	19982	0.06	5	100	5	1198.9	500.0	1700	1700	9675	9675	12990	12990	**3315**
005	LL1	Short Stay Exterior	2380	0	10	24	25	0.0	600.0	600	600	4544	4545	1550	4545	**5**
005	LL1	Blood Draw	856	0	20	18	15	0.0	270.0	270	270	1126	1130	560	1130	**5**
005	LL1	Interior Exam Rooms	3621	0	10	37	25	0.0	925.0	925	925	3214	3215	2355	3215	**5**
006	LL1	Exterior Pre/Post	2147	0	20	43	25	0.0	1075.0	1075	1835	1772	1775	1400	1835	**65**
006	LL1	Interior Pre/Post	2816	0	20	57	25	0.0	1425.0	1425	9320	1443	1445	1835	9320	**7880**
007	L1	OR Int	12165	0	20	244	30	0.0	7320.0	7320	9320	9316	9320	7910	9320	**5**
007	LL1	Interior Proceudre Room	5113	0	20	103	15	0.0	1545.0	1545	3225	3223	3225	3325	3225	**5**
007	LL1	X-Ray	1944	0	20	39	15	0.0	585.0	585	1265	1048	1050	1265	1265	**220**
008	LL1	Misc Exterior	2226	0.06	5	12	5	133.6	60.0	195	195	1723	1725	1450	1725	**5**
008	LL1	Business Center	5418	0.06	50	271	5	325.1	1355.0	1685	1685	2536	2540	3525	3525	**990**
008	LL1	Ext Office Area	1744	0.06	50	88	5	104.6	440.0	545	545	8774	8775	1135	8775	**5**
008	LL1	Decontam Storage	1005	0.12	0	0	0	120.6	0.0	125	125	337	340	655	655	**320**
008	LL1	Waiting	2227	0.06	30	67	5	133.6	335.0	470	470	4893	4895	1450	4895	**5**
008	LL1	Mechanical	3441	0.12	0	0	0	412.9	0.0	415	415	2164	2165	2240	2240	**80**
008	LL1	Office/Storage	23476	0.06	5	118	5	1408.6	590.0	2000	2000	12822	12825	15260	15260	**2440**
009	L1	Pharmacy	571	0.18	10	6	5	102.8	30.0	135	375	387	390	375	375	**-10**
009	L1	Exterior Pre/Post Room	2817	0	20	57	25	0.0	1425.0	1425	4860	4860	4860	1835	4860	**0**
010	L1	Interior Pre/Post	3912	0	20	79	25	0.0	1975.0	1975	2545	1672	1675	2545	2545	**875**
010	L1	Exterior Short Stay	2377	0.06	10	24	25	142.6	600.0	745	2205	2202	2205	1550	2205	**5**
011	L1	Exterior Corridor	3991	0.06	0	0	0	239.5	0.0	240	240	2684	2685	2595	2685	**5**
011	L1	Mechanical	3251	0.12	0	0	0	390.1	0.0	395	395	2200	2200	2115	2200	**0**
011	L1	Interior Office Area	29589	0.06	50	1480	5	1775.3	7400.0	9180	9180	14115	14115	19235	19235	**5120**
011	L1	PACU	501	0	20	11	10	0.0	110.0	110	110	201	205	330	330	**130**
012	L2	NICU Exterior North	5339	0	10	54	25	0.0	1350.0	1350	9530	9530	9530	3475	9530	**0**
012	L2	NICU Exterior East	1348	0	10	14	25	0.0	350.0	350	4555	4554	4555	880	4555	**5**
013	L2	NICU South Interior	1885	0	10	19	25	0.0	475.0	475	1055	1055	1055	1230	1055	**0**
013	L2	NICU West	2540	0	10	26	25	0.0	650.0	650	2450	2450	2450	1655	2450	**0**
014	L2	Interior Offices/Storage/Corridor	26948	0.06	5	135	5	1616.9	675.0	2295	2295	13043	13045	17520	17520	**4480**
014	L3	Interior Office/Waiting	16770	0.06	30	504	5	1006.2	2520.0	3530	3530	11463	11465	10905	11465	**5**
015	L2	NICU MRI	340	0	20	7	15	0.0	105.0	105	225	212	215	225	225	**15**
015	L3	C-Section & OR	1210	0	20	25	15	0.0	375.0	375	920	918	920	790	920	**5**
016	L3	Delivery	2879	0	20	58	15	0.0	870.0	870	870	7505	7505	1875	7505	**0**
016	L3	Exam Room	1297	0	20	26	15	0.0	390.0	390	390	4808	4810	845	4810	**5**
017	L4	Patient Room North	6352	0	10	64	25	0.0	1600.0	1600	10150	10146	10150	4130	10150	**5**
017	L4	Patient Room East	1647	0	10	17	25	0.0	425.0	425	1505	1503	1505	1075	1505	**5**
018	L4	Patient Room South	2132	0	10	22	25	0.0	550.0	550	1775	1771	1775	1390	1775	**5**
018	L4	Patient Room West	3163	0	10	32	25	0.0	800.0	800	8475	8471	8475	2060	8475	**5**
019	L4	Office Area	20489	0.06	5	103	5	1229.3	515.0	1745	1745	10141	10145	13320	13320	**3180**
019	L4	Mech/Elec/Elevator	2684	0.12	0	0	0	322.1	0.0	325	325	1413	1415	1745	1745	**335**
019	L4	Cardiac Call	269	0.06	10	3	25	16.1	75.0	95	95	101	105	175	175	**75**
020	L4	Important Storage	2666	0.12	0	0	0	319.9	0.0	320	1735	882	885	1735	1735	**855**
020	L5	Important Storage	2666	0.12	0	0	0	319.9	0.0	320	1735	29	30	1735	1735	**1710**
020	L6	Medical Storage	1854	0.12	0	0	0	222.5	0.0	225	1210	667	670	1210	1210	**545**
021	L5	Patient Room North	6352	0	10	64	25	0.0	1600.0	1600	10700	10696	10700	4130	10700	**5**
021	L5	Patient Room East	1647	0	10	17	25	0.0	425.0	425	4400	4396	4400	1075	4400	**5**
022	L5	Patient Room South	2132	0	10	22	25	0.0	550.0	550	4975	4972	4975	1390	4975	**5**
022	L5	Patient Room West	3163	0	10	32	25	0.0	800.0	800	7320	7318	7320	2060	7320	**5**
023	L5	Office/Family/Waiting	20489	0.06	30	615	5	1229.3	3075.0	4305	4305	9926	9930	13320	13320	**3395**
023	L5	Mech/Elec/Elevator	2684	0.12	0	0	0	322.1	0.0	325	325	1622	1625	1745	1745	**125**
023	L5	PICU Call	269	0.06	10	3	25	16.1	75.0	95	95	44	45	175	175	**135**
023	L6	Mech/Elec/Stor	2871	0.12	0	0	0	344.5	0.0	345	345	1717	1720	1870	1870	**155**
023	L6	Office Area	9562	0.06	5	48	5	573.7	240.0	815	815	9630	9630	6220	9630	**0**
023	L7	Mech/Elec/Elevator	23241	0.12	0	0	0	2788.9	0.0	2790	2790	16225	16225	15110	16225	**0**
023	L8	Mech/Elec/Elevator	2933	0.12	0	0	0	352.0	0.0	355	355	2855	2855	1910	2855	**0**
024	L6	Exterior Patient Room North	6206	0	10	63	25	0.0	1575.0	1575	10040	10039	10040	4035	10040	**5**
024	L6	Exterior Patient Room East	1701	0	10	18	25	0.0	450.0	450	4995	4993	4995	1110	4995	**5**
F-001	L3	Shell	17357					0.0	0.0	0				11285		**0**
F-002	L6	Shell	10161					0.0	0.0	0				6605		**0**
F-003	L7	Shell	16414					0.0	0.0	0				10670		**0**
		TOTAL AREA:	464523						**VENTILATION CFM:**	**84680**	**187805**	**TRACE CFM:**	**341490**	**ADDITIONAL REQUIRED CFM:**		**44320**

Domestic Water Service

Fixtures	Quantity	Cold Fixt. Units	Total Cold Fixt. Units	Cold GPM	Hot Fixt. Units	Total Hot Fixt. Units	Hot GPM	Total GPM
Lavatories	260	1.5	390	125	1.5	390	103	228
Kitchen Sinks	40	3	120	73	3	120	48	121
Service Sinks	115	2.25	258.75	102.225	2.25	258.75	76.75	178.975
Water Closets	275	10	2750	406.5	0	0	0	406.5
Showers	150	3	450	135	3	450	95	230
Urinals	10	10	100	67.5	0	0	0	67.5
Refrigerator	9	0.25	2.25	5.375	0	0	0	5.375
Washing Machine	3	3	9	24.6	0	0	0	24.6
							Total:	1262
							Size:	8"

Sanitary Drainage

Fixtures	Quantity	DFUs/Fixture	Total DFUs
Lavatories	260	1	260
Kitchen Sinks	40	2	80
Service Sinks	115	2	230
Water Closets	275	4	1100
Showers	150	3	450
Urinals	10	2	20
Floor Drains	350	2	700
		Total:	2840
		Size:	10"

Medical Air

Space Type	Quantity	SCFM Per Room	SCFM Per Bed	SCFM Per Outlet	Simultanious Use Factor	SCFM
Anesthetizing Locations						
Major Surgery	12	0.5			100%	6
Delivery/C-Section	2	0.5			100%	1
Acute Care						
CCU/PICU	64		2.0		75%	96
NICU	33		1.5		50%	24.75
OB Recovery/PACU	8		2.0		25%	4
Subacute Care						
Patient Room	96	0.5			50%	24
LDRP	5	1.0			10%	0.5
Exam/Treatment/Procedure	22	1.0			10%	2.2
Other Care Areas						
Anesthesia Work	1	1.5			10%	0.15
					Subtotal	158.6
				Dessicant Dryer Purge	15%	23.79
				Future Expansion	20%	31.72
					Total Required SCFM	214

Natural Gas Calculations

Equipment	MBH
Commercial Range	360
Convection Oven	108
2 Boilers	66950
2 Domestic Boilers	2600
2 Kitchen Boiler	1840
TOTAL	71858
Size	12"

***Assume Length = 200 ft

Fire Protection

Building Area	464523
Area/Sprinkler Head	225
Minimum Quantity of Heads	2065
Sizing Adjustment (115%)	2374
Service Entrance Size	12"

Nitrous Oxide Cylinder Manifold

Anesthetising Locations	Primary Cylinders	Secondary Cylinders
14	7	7

Vacuum System

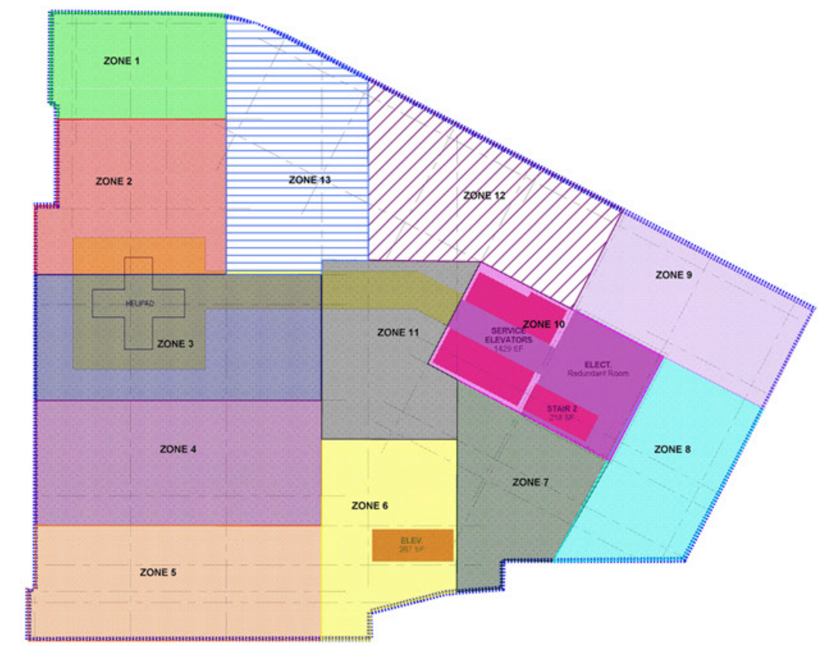
Space Type	Quantity	SCFM Per Room	SCFM Per Bed	SCFM Per Inlet	Simultanious Use Factor	SCFM
Anesthetizing Locations						
Major Surgery	12	3.5			100%	42
Delivery/C-Section	2	1.0			100%	2
Waste Anesthetic Gas Disposal	6	1.0			100%	6
Acute Care						
CCU/PICU	64		2.0		75%	96
NICU	33		1.0		50%	16.5
OB Recovery	2		2.0		50%	2
PACU	6		3.0		50%	9
Subacute Care						
Patient Room - surgical	56		1.5		50%	42
Patient Room - medical	40		1.0		25%	10
LDRP	5		1.0		10%	0.5
Exam/Treatment/Procedure	22			1.0	10%	2.2
Other Care Areas						
Sterile/Clean Supply	25			1.5	10%	3.75
Anesthesia Work	1			1.5	10%	0.15
Meds/Pharmacy	21			1.0	10%	2.1
					Subtotal	234.2
				Future Expansion	20%	46.84
					Total Required SCFM	281

Oxygen Storage

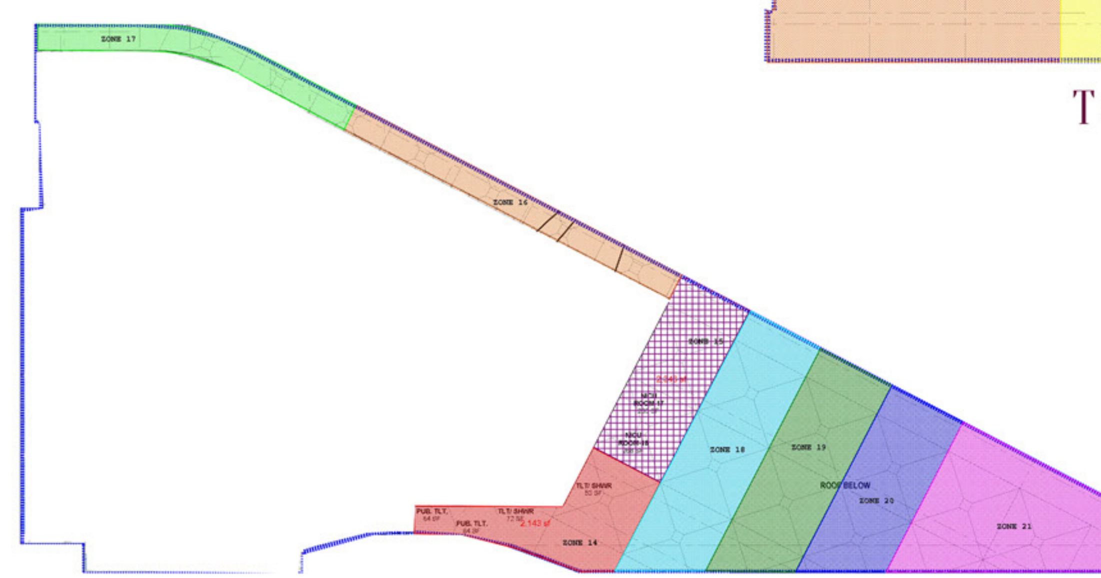
Room Type	Quantity	Demand per Room (ft^3)	Total
Non-acute Care	43	500	21500
Acute Care	190	1000	190000
		Total (cf)	253800

Roof Drain

Zone	Area	Wall Height	Wall Length	HPA	Total Area	GPM	Drain Size
		Horizontal Projected Area					
1	2082	0	0	0	2082	81	4
2	3113	0	0	0	3113	121	6
3	4076	0	0	0	4076	159	6
4	4052	0	0	0	4052	158	6
5	3711	0	0	0	3711	145	6
6	2648	0	0	0	2648	103	4
7	2237	0	0	0	2237	87	4
8	2532	0	0	0	2532	99	4
9	2690	0	0	0	2690	105	4
10	2688	0	0	0	2688	105	4
11	2643	0	0	0	2643	103	4
12	3574	0	0	0	3574	139	6
13	3608	0	0	0	3608	141	6
14	2143	46	93	4278	6421	250	6
15	2346	46	67	3082	5428	212	6
16	1511	46	137.5	6325	7836	306	6
17	1511	46	137.5	6325	7836	306	6
18	3443	0	0	0	3443	134	6
19	2925	0	0	0	2925	114	4
20	2405	0	0	0	2405	94	4
21	3576	0	0	0	3576	139	6

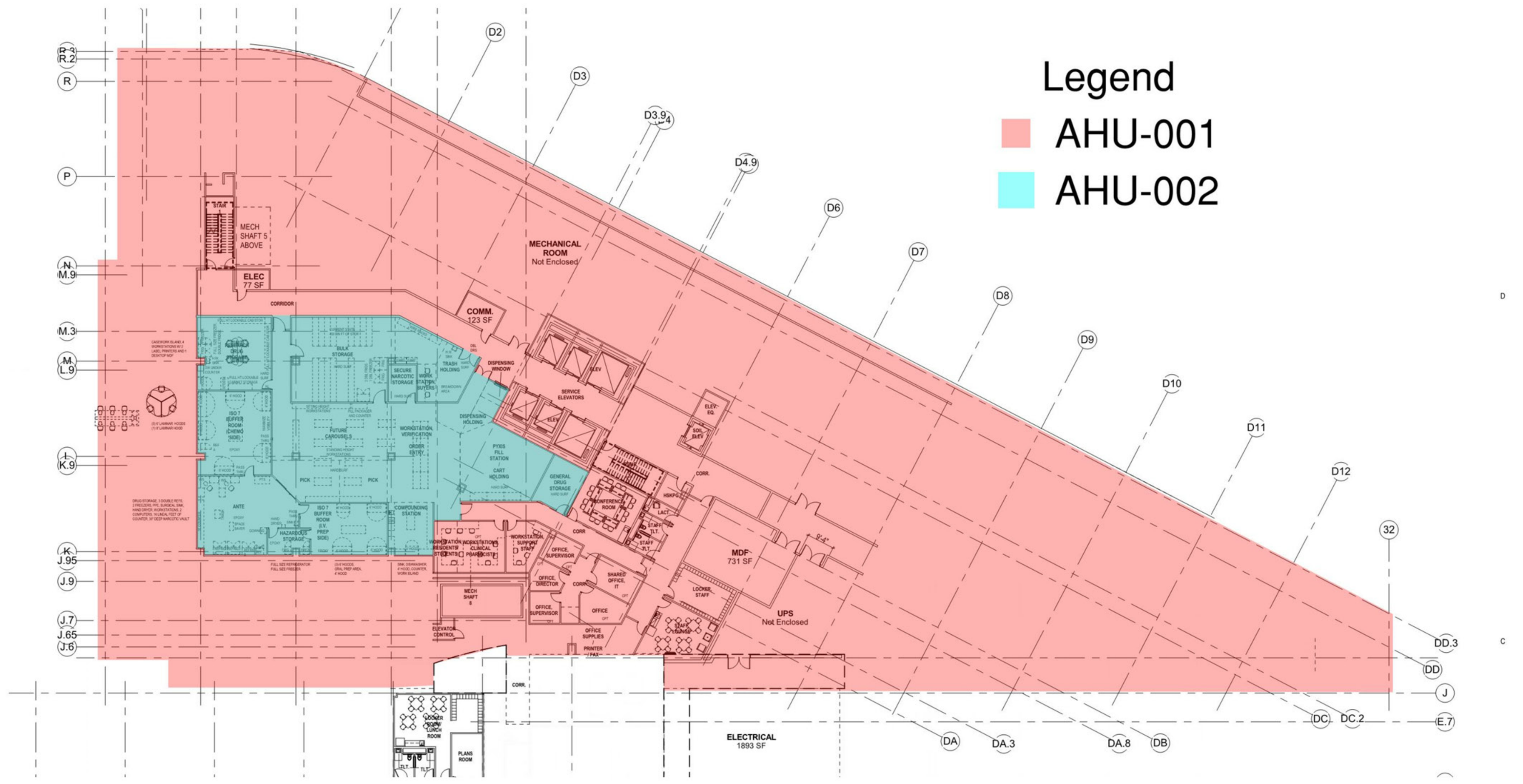


TOP ROOF ZONES

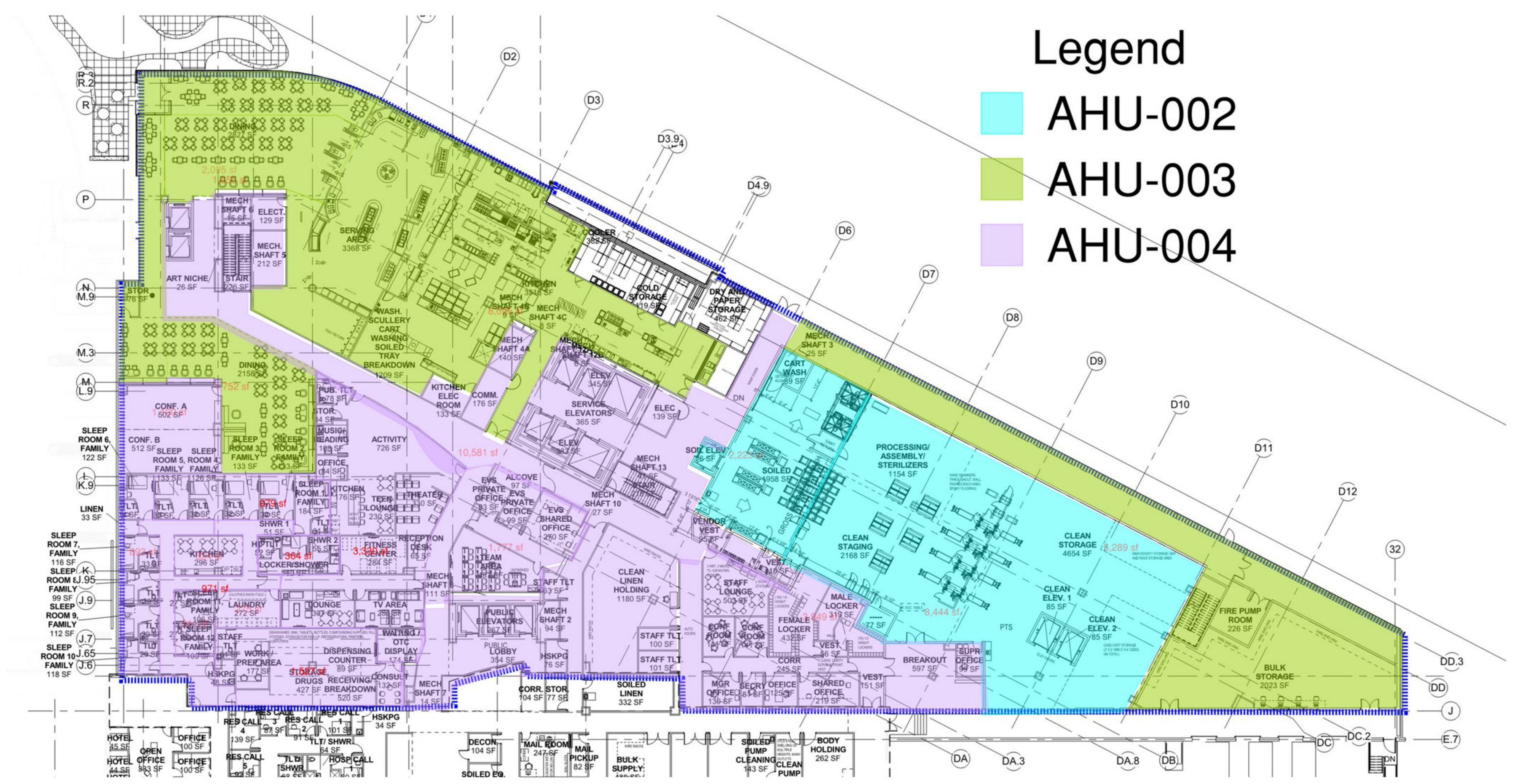


LOWER ROOF ZONES

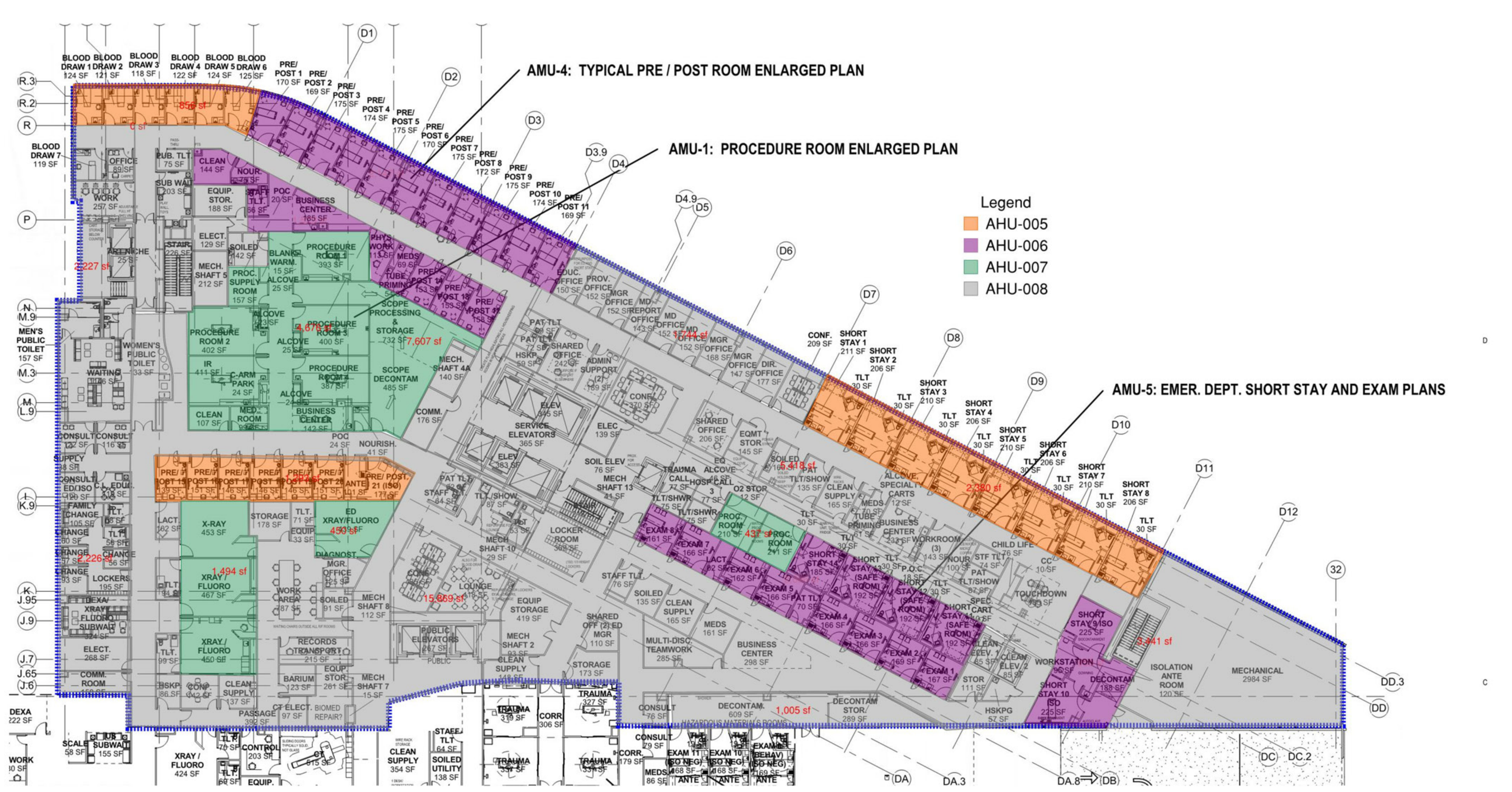
THE ZONING PLANS SHOW THE DESIGNANTED ARES FOR EACH AHU'S DISTRIBUTION.



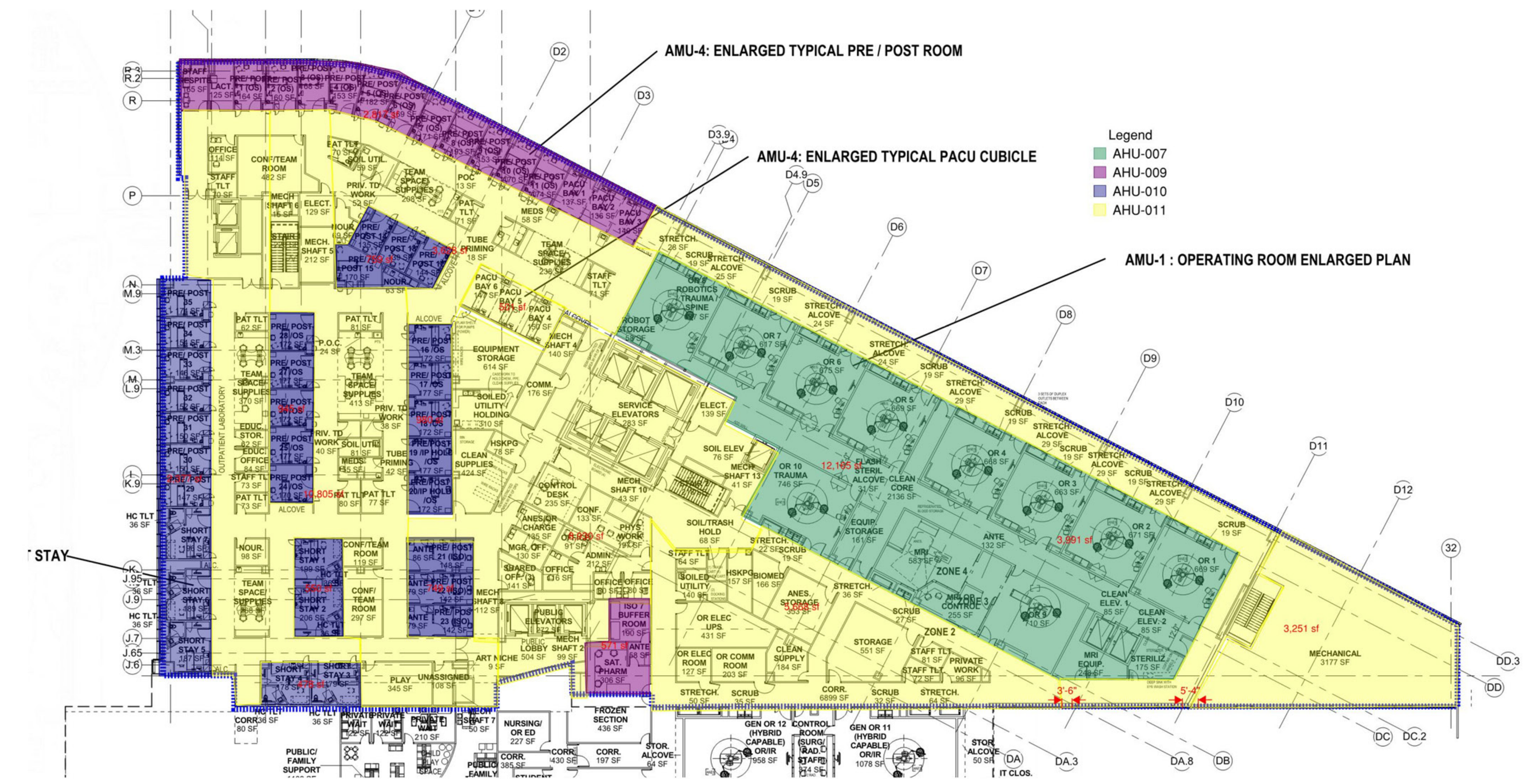
1 AHU ZONING PLAN LOWER LEVEL 5
1" = 60'-0"



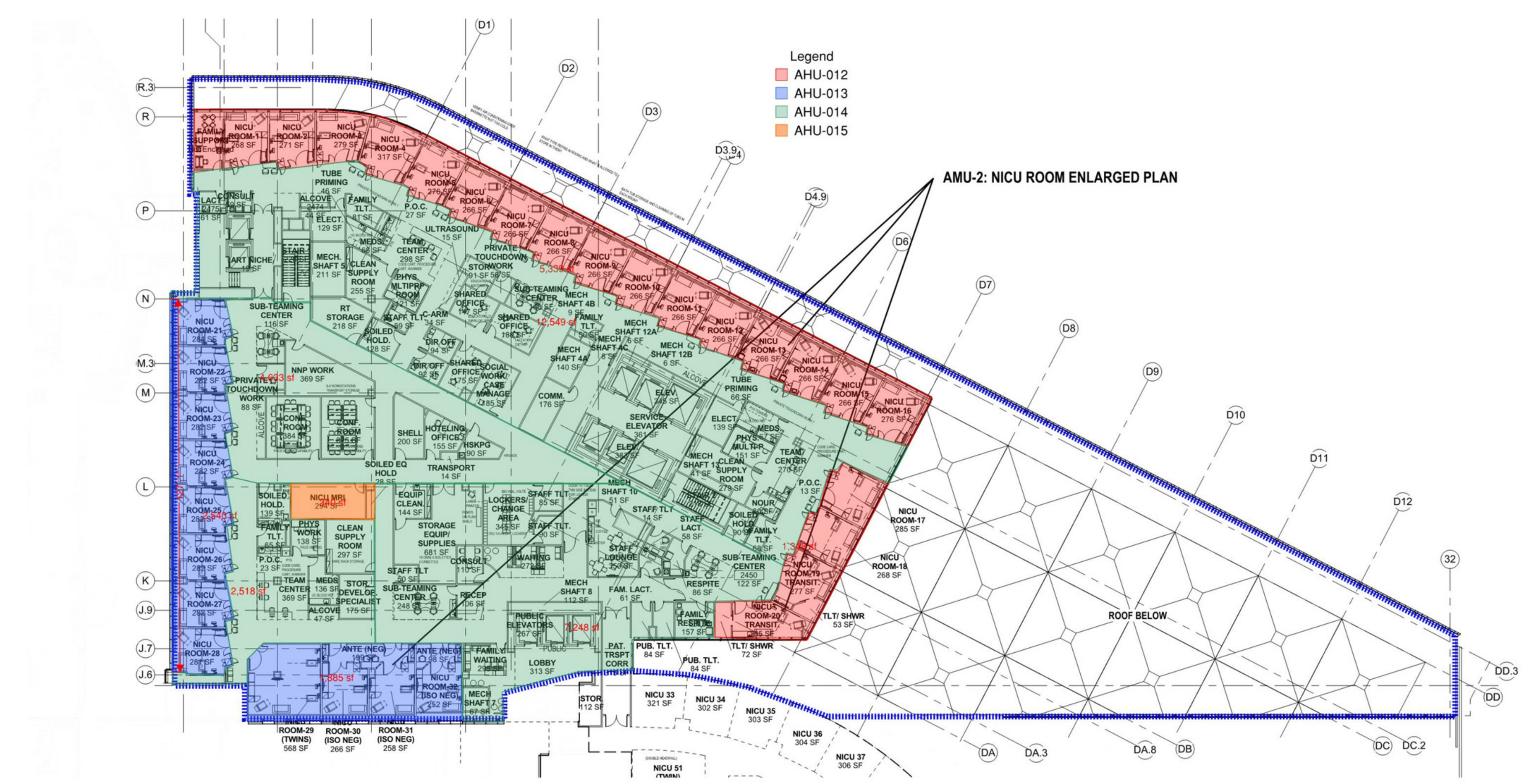
2 AHU ZONING PLAN LOWER LEVEL 3
1" = 60'-0"



3 AHU ZONING PLAN LOWER LEVEL 1
1" = 60'-0"



4 AHU ZONING PLAN LEVEL 1
1" = 60'-0"



5 AHU ZONING PLAN LEVEL 2
1" = 60'-0"

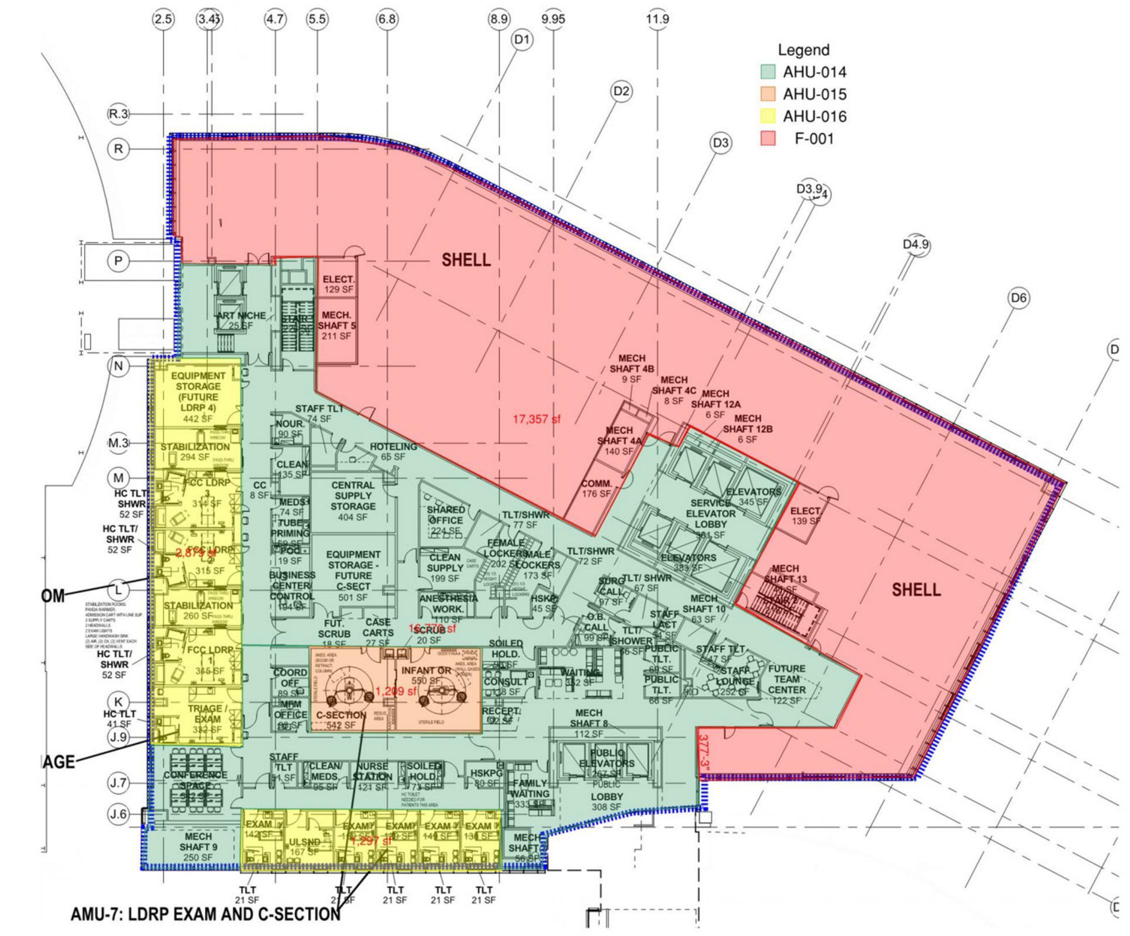
MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
ZONING PLANS

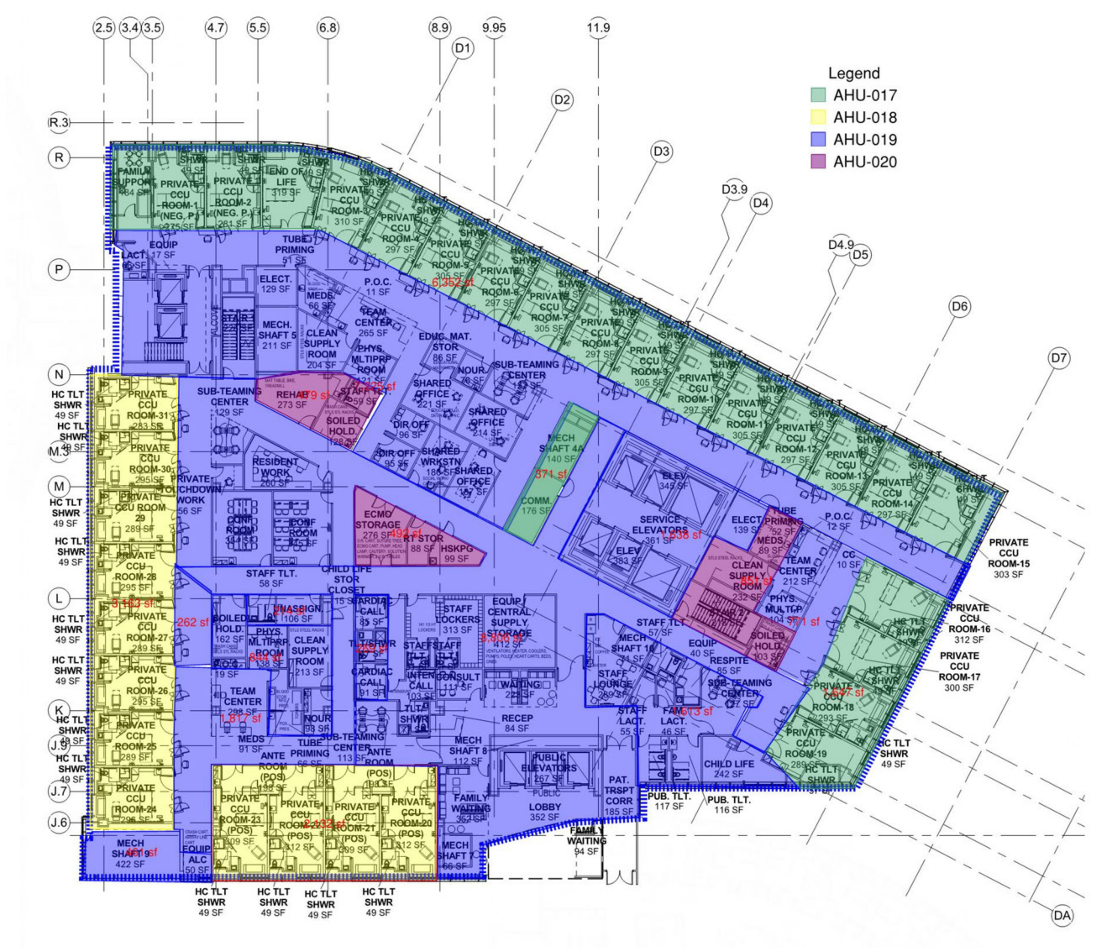
M-101

THE ZONING PLANS SHOW THE DESIGNANTED ARES FOR EACH AHU'S DISTRIBUTION.

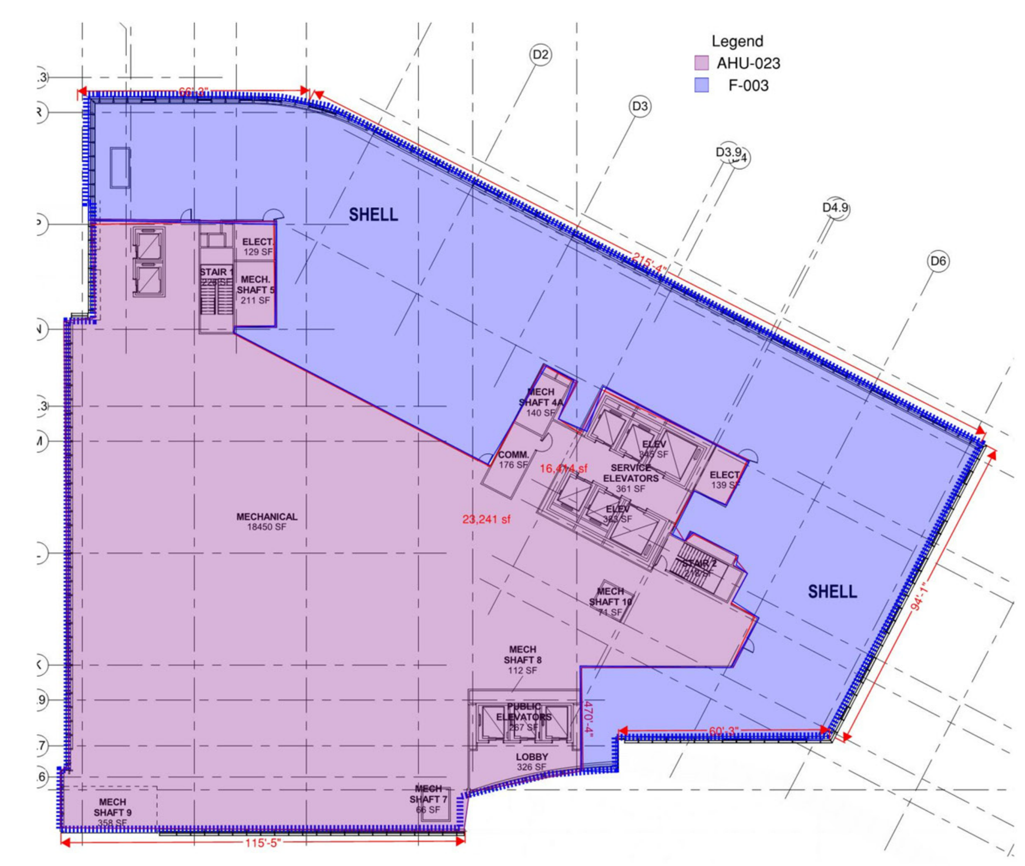


1 AHU ZONING PLAN LEVEL 3
1" = 60'-0"

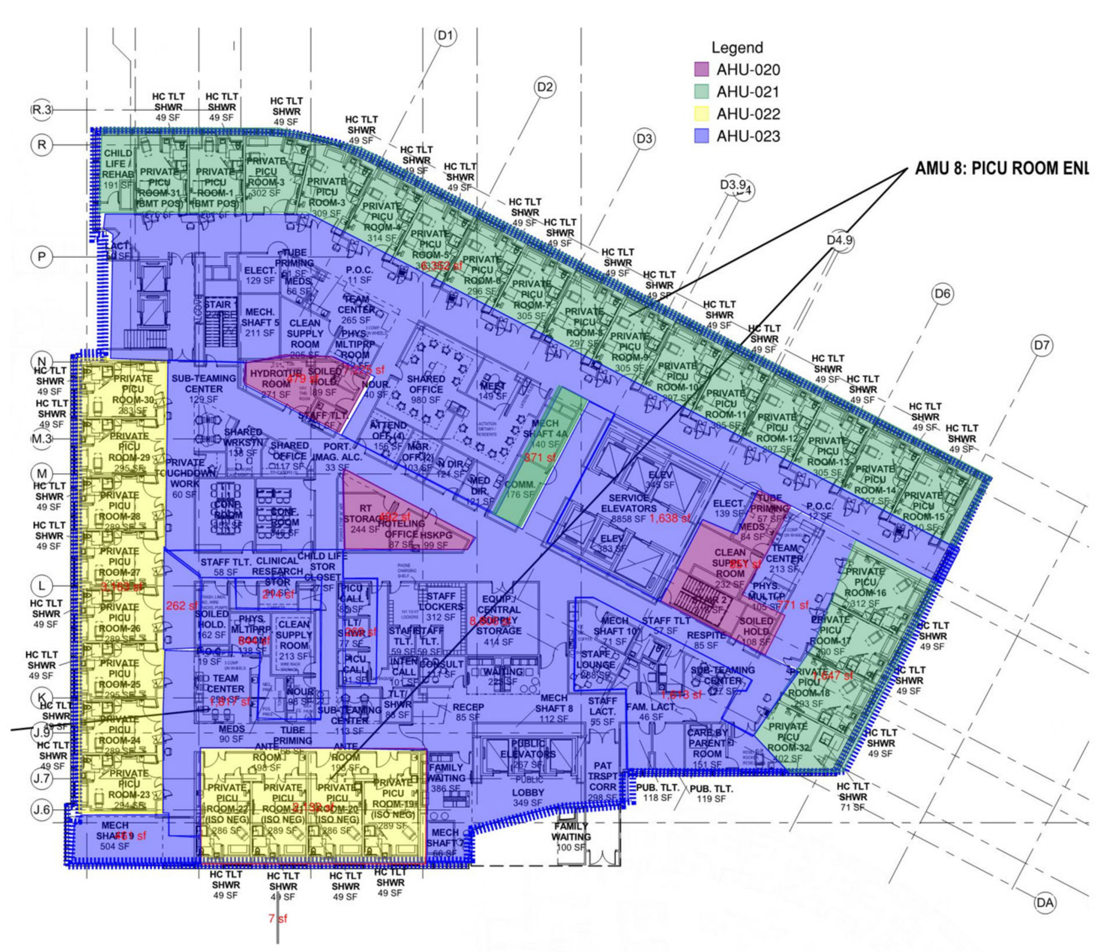
4 AHU ZONING PLAN LEVEL 6
1" = 60'-0"



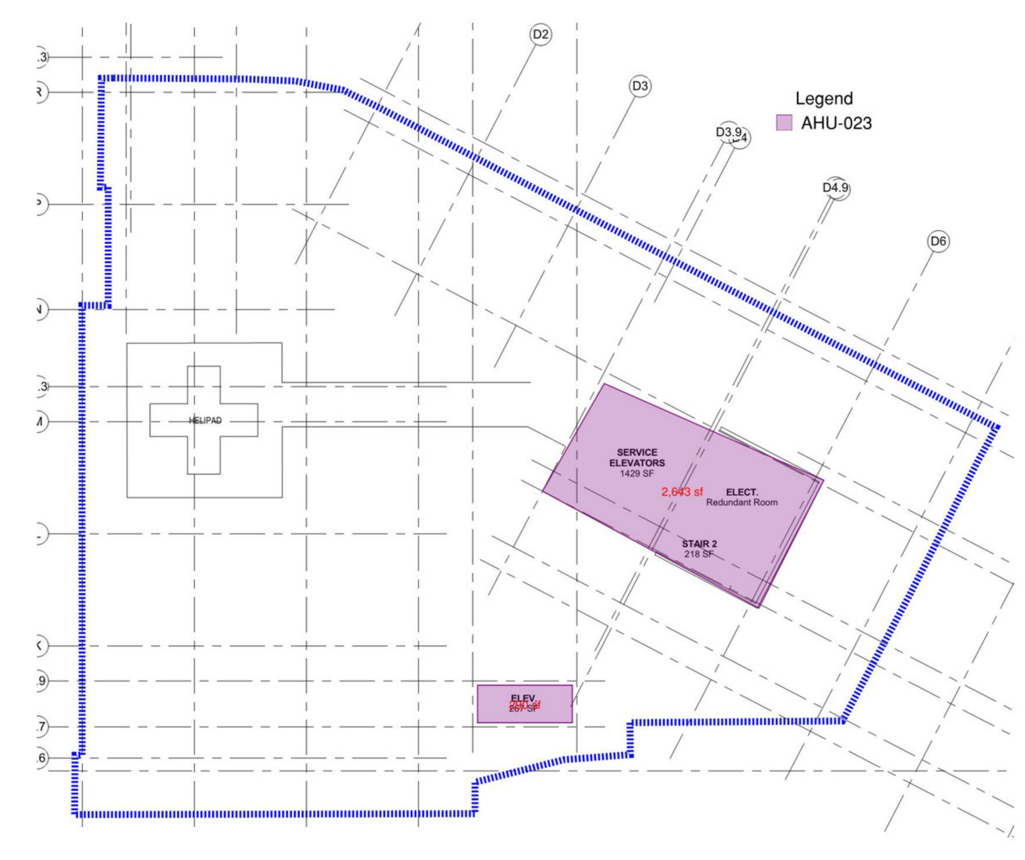
2 AHU ZONING PLAN LEVEL 4
1" = 60'-0"



5 AHU ZONING PLAN LEVEL 7
1" = 60'-0"



3 AHU ZONING PLAN LEVEL 5
1" = 60'-0"



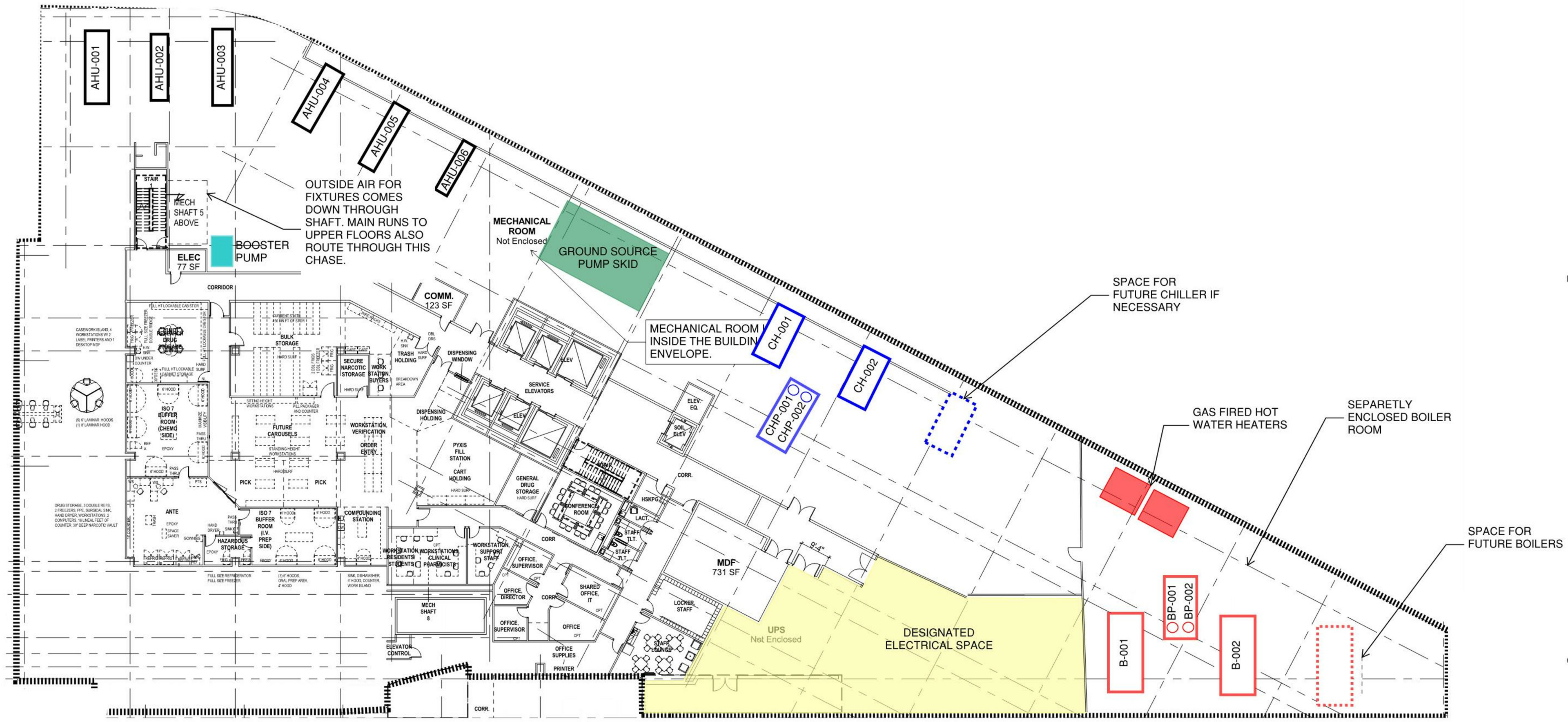
6 AHU ZONING PLAN LEVEL 8
1" = 60'-0"

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
ZONING PLANS

M-102



1/16" = 1'

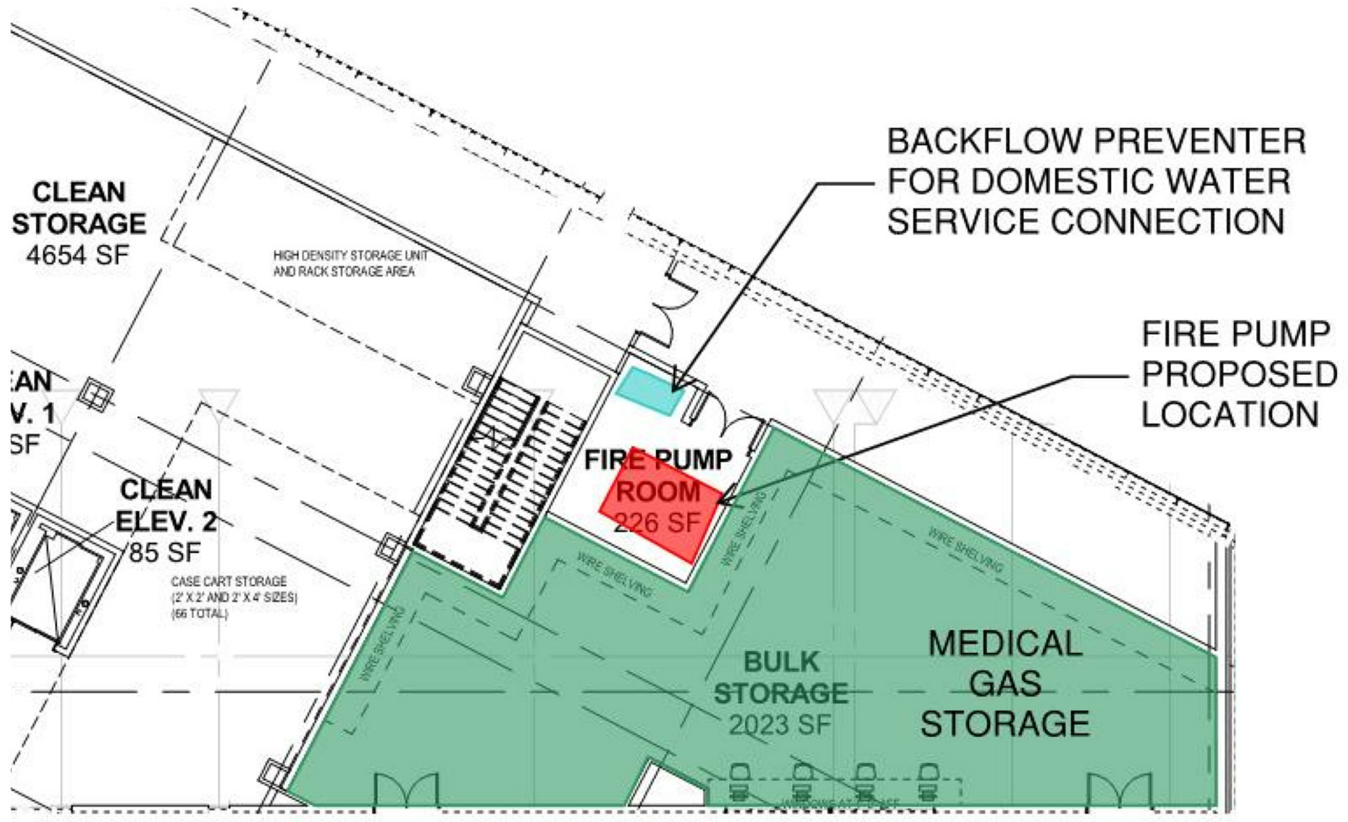
1 LOWER LEVEL 5 CENTRAL PLANT MECHANICAL ROOM
1/32" = 1'-0"

MUREX
EST 2017-18

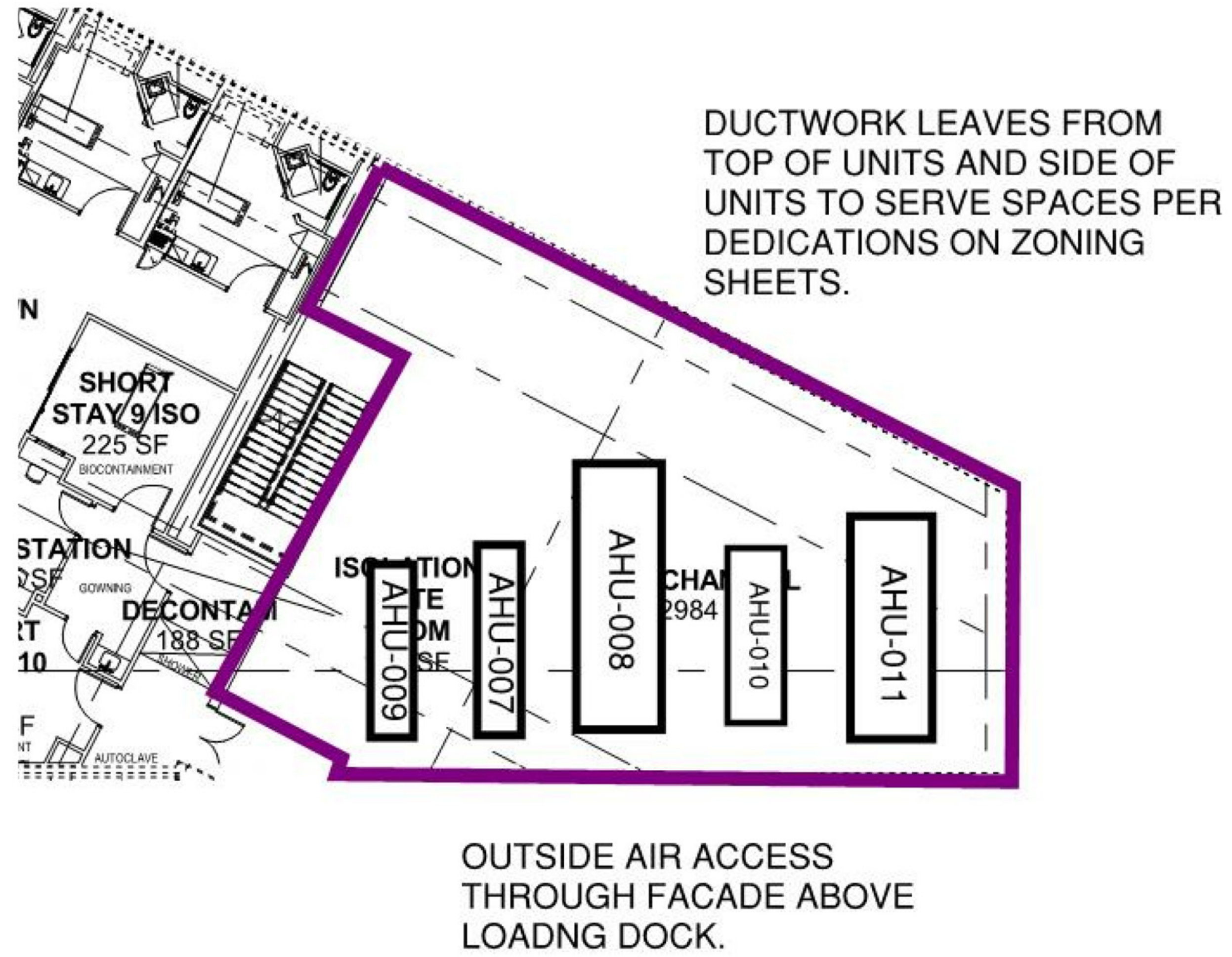
PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
MECHANICAL ROOM LAYOUTS

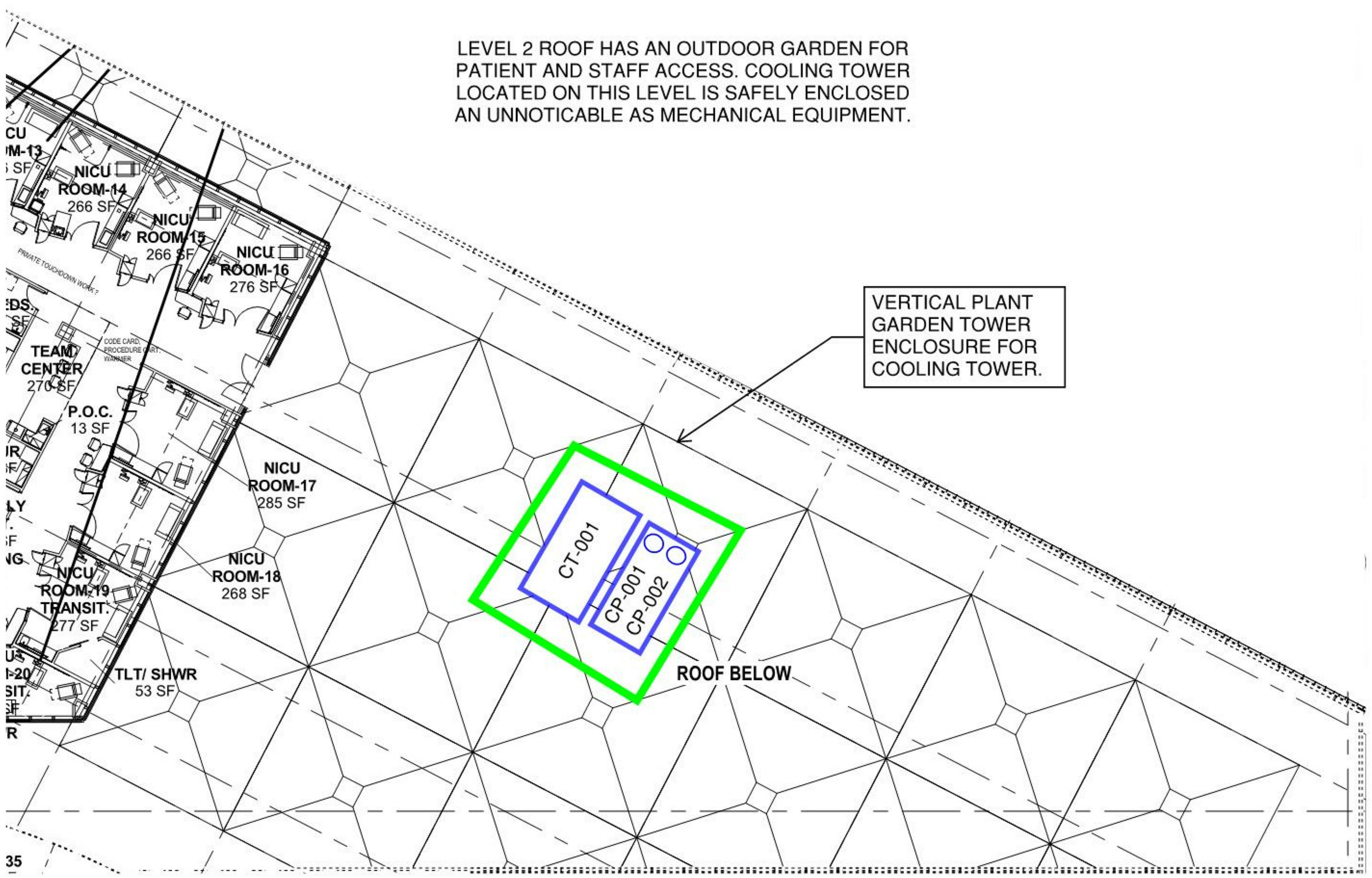
M-103



LOWER LEVEL 3 MECHANICAL SPACES PLAN
1
1/16" = 1'



LOWER LEVEL 1 MECHANICAL SPACES PLAN
2
1/16" = 1'



LOWER LEVEL ROOF MECHANICAL PLAN
4
1/16" = 1'

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PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
MECHANICAL ROOM LAYOUTS

M-104

DUCTWORK LEAVES FROM SIDE OF UNITS AND DIRECTED DOWN TO SERVE SPACES PER DEDICATIONS ON ZONING SHEETS.

OUTSIDE AIR ACCESS THROUGH LOUVERS ON ROOF.

1 LEVEL 7 MECHANICAL PENTHOUSE PLAN
1/16" = 1'

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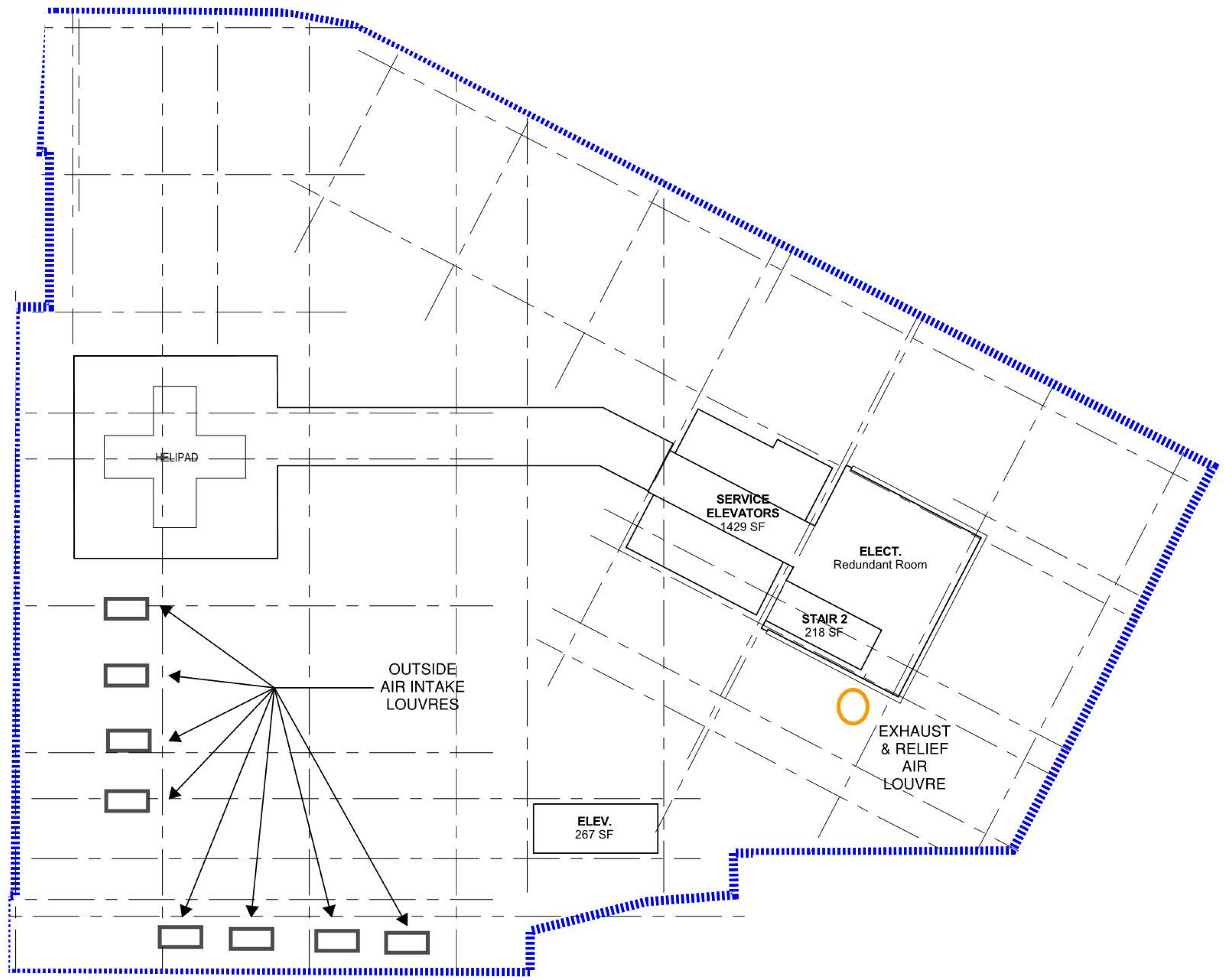
PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
MECHANICAL ROOM LAYOUTS

M-105



1 LEVEL 8 ROOF MECHANICAL PLAN
1/16" = 1'

MUREX
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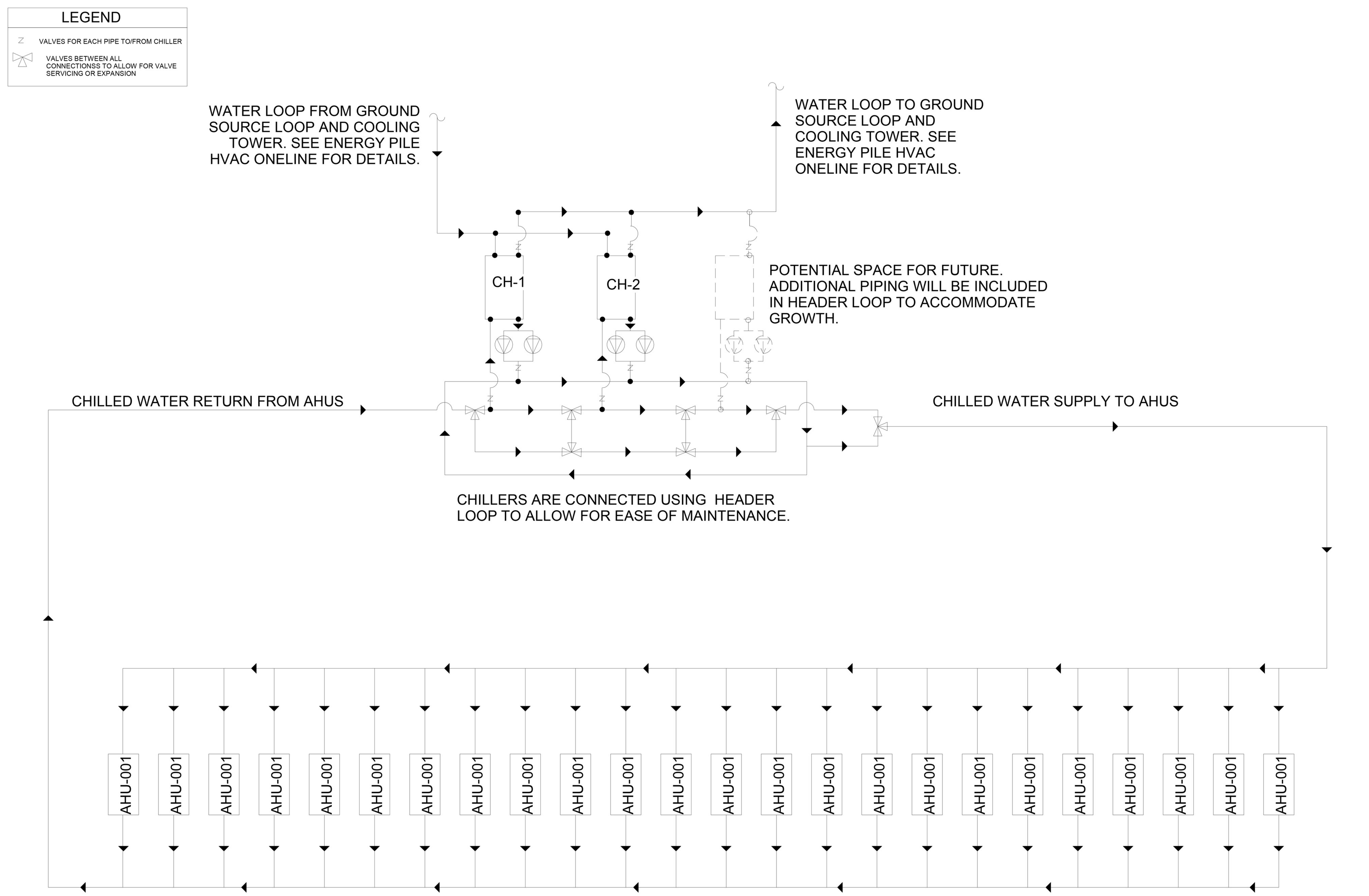
PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
MECHANICAL ROOM LAYOUTS

M-106



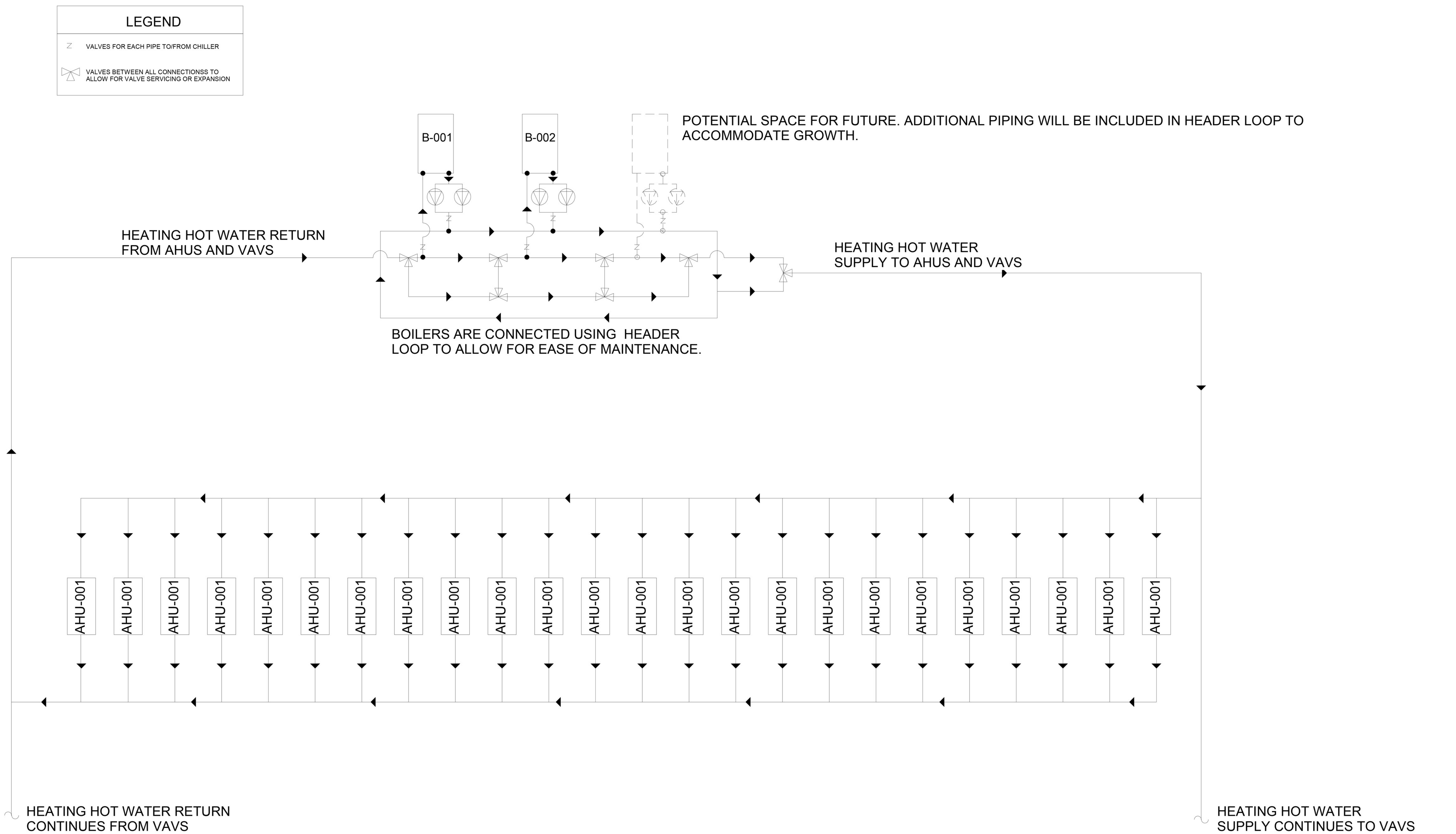
1 HVAC COOLING ONELINE
NTS

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
HVAC COOLING ONLINE

M-107



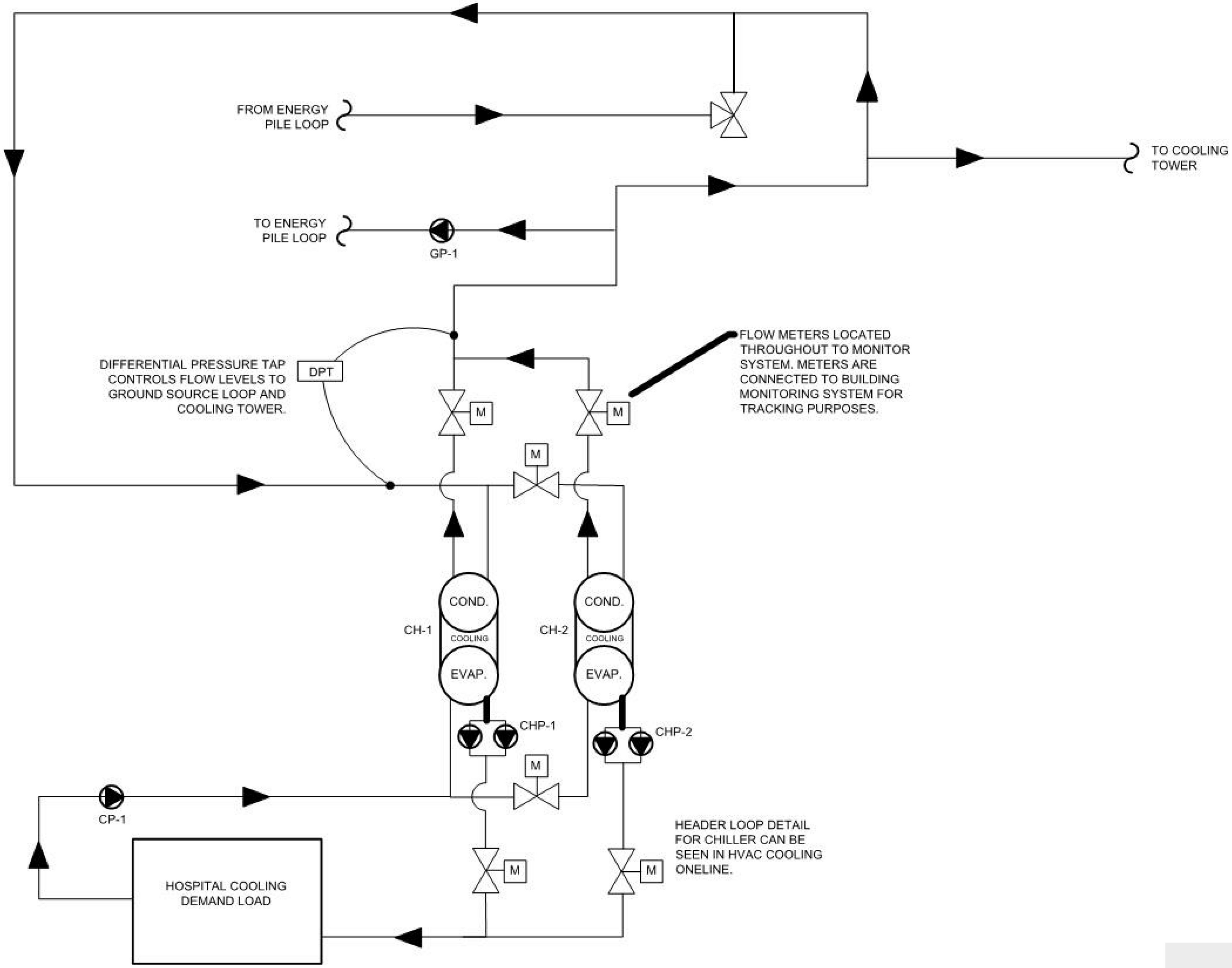
1 HVAC HEATING ONELINE
NTS

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
HVAC HEATING ONLINE

M-108



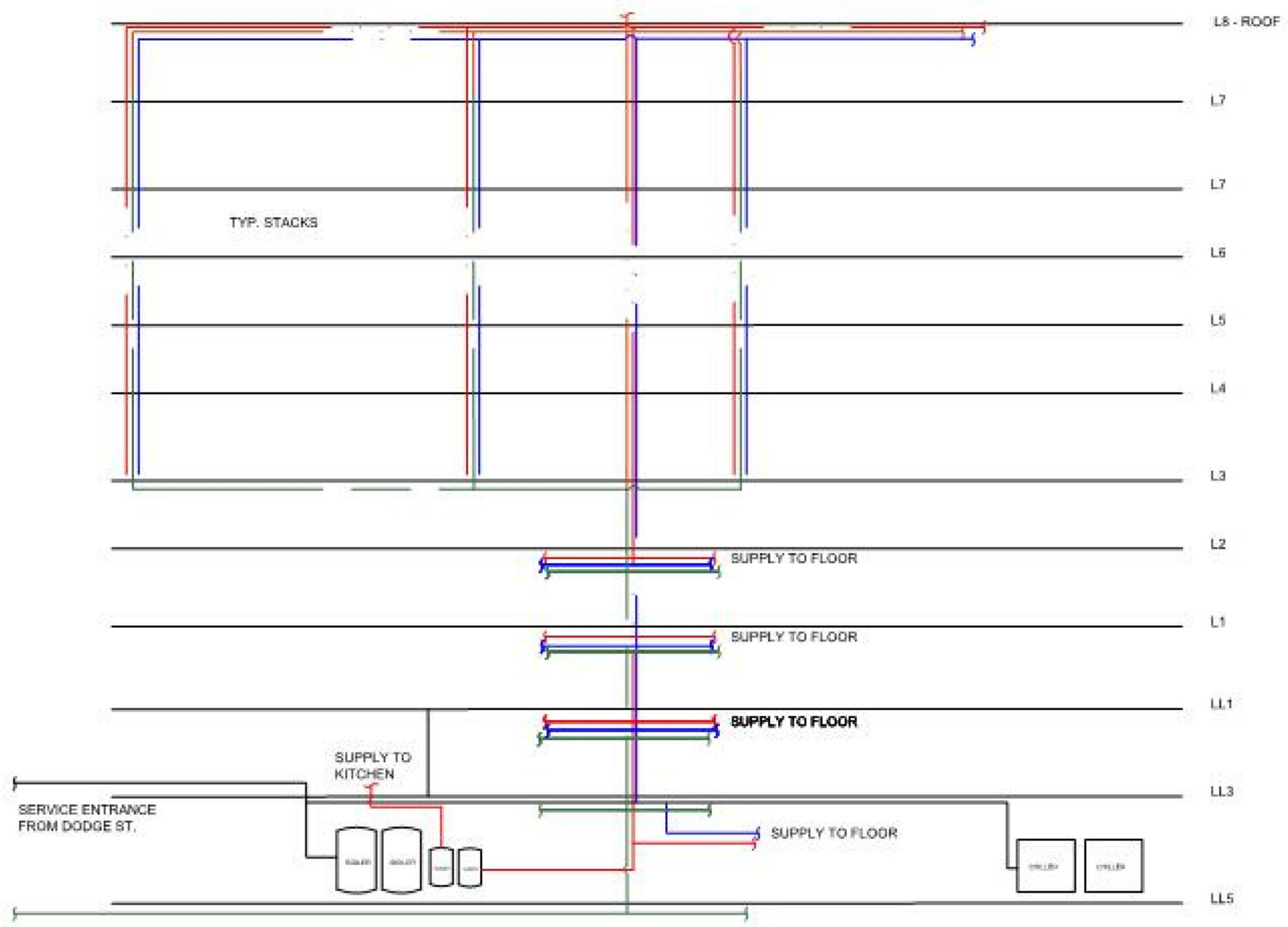
1 ENERGY PILE HVAC ONE LINE
NTS

MUREX
EST 2017-18

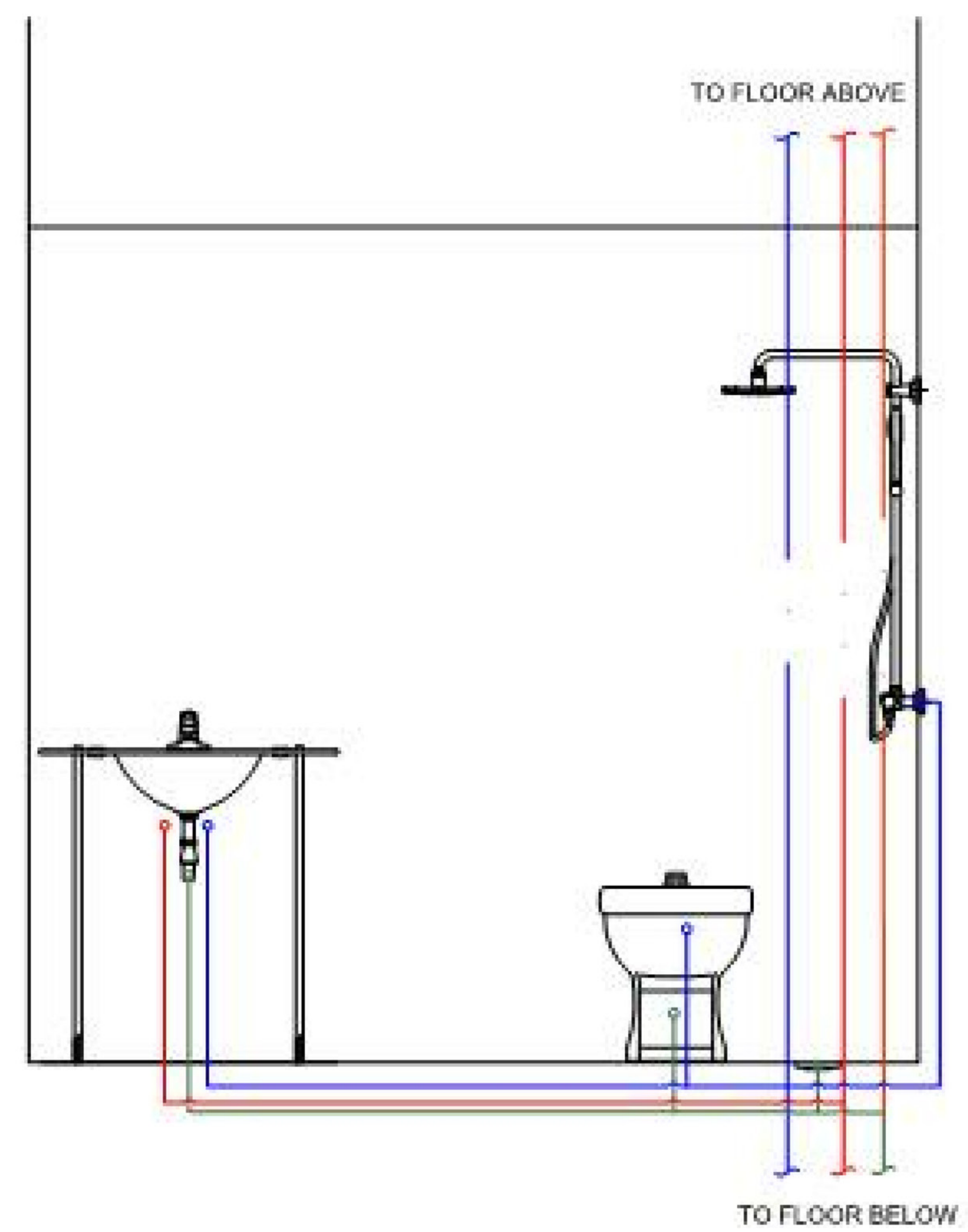
PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
GROUND LOOP HVAC ONE LINES

M-109



1 PLUMBING RISER
NTS



2 TYPICAL RESTROOM PLUMBING RISER
NTS

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
PLUMBING DETAILS

M-110

4.1.0 Executive Summary

Murex has provided the preliminary design for the Children's Hospital and Medical Center in Omaha Nebraska. The facility is a 10 floor, 460,000 square foot healthcare facility. This submittal will cover all electrical system designs as well as the integration with all other systems to a design development level.

4.1.1 Introduction

The goals and designs of Murex are based on the principles of safety, integrity, and sustainability as outlined in the Architectural Engineering Institute Build Initiative. Murex believes these initiatives best serve the interest of the building owner and the community the building will affect. It is our goal to provide design that has a positive and lasting impact for all who come in contact with it.

4.1.2 Project Description

The facility is a new construction on an existing campus, providing additions to the NICU and PICU, as well as adding a CCU and Fetal Care Program.This new ten story tower and four story ancillary podium is located adjacent to West Dodge Road, one of the main roads through Omaha. Throughout the electrical design, Murex wanted to deliver solutions to the overall project challenges set, as well as align with the individual internal team goals. With this in mind, Murex has decided to focus its design on maximizing safety, integrity, and sustainability to create a cohesive, efficient design.

4.1.3 Design Goals

Murex's electrical design team has set two overall goals:

maingoals

1. Provide a building that provides the safest possible environment whether in normal, emergency, or disaster operations.
2. Provide a design that allows for a comfortable and personalized experience for each patient and their family, as well as the professionals working there.

subgoals

Patient Control and Comfort

The first and foremost concern of the hospital is to provide top of the line care to its patients. To alleviate the stress of being in an uncomfortable or frightening new area, patients have options and freedom in each room to fit their needs.

Highly Efficient Systems

The main electrical equipment and light systems have controls that when operated properly will reduce energy usage and increase efficiency.

Cost Effective Choices

as a midwestern city, overall cost is extremely important, and including solutions that maximized performance while reducing cost were integral.

Reliability

The design has redundancy throughout to excel in situations of emergency or disaster.

4.1.4 Design Solutions

The Murex design team carefully selected the components of the design in cooperation with all disciplines to find solutions that complimented each others' designs. The design goals described above were other driving factors in the process.

Building Monitoring System

The building monitoring system will integrate with the MEP systems to improve efficiency and allow individualized patient control for improved comfort. It will also allow patients and any guests in the building to see the energy savings throughout the building and their impact. This is a useful tool in that it allows for customization for the user, while being connected to every control throughout the building, whether it be lighting, healthcare specific, or HVAC.

4. ELECTRICAL NARRATIVE

4.1.0 Executive Summary
4.2.0 Project Introduction
4.2.1 Goals
4.2.2 AEI Build Initiatives
4.2.3 Challenges
4.2.4 Codes & Standards
4.3.0 Design Solutions
4.3.1 Power Generation
4.3.2 Power Distribution System
4.3.3 Lighting and Controls
4.4.0 Special Systems
4.4.1 Security System
4.4.2 Building Monitoring System
4.4.3 Specialty Healthcare Controls System
4.4.4 Fire Alarm
4.5.0 Integration
4.5.1 Integrated Project Delivery
4.5.2 Structural Integration
4.5.3 Mechanical Integration
4.6.0 Conclusion

4.2.0 Introduction

The 2018 AEI Student Design Competition proposed the challenge of designing the Children's Hospital and Medical Center new addition in Omaha, Nebraska. The building is approximately 460,000 square feet, with typical hospital spaces, as well as PICU, NICU, Fetal Care Program, and CCU floors.This new ten story tower and four story ancillary podium project site is located right off one of Omaha's busiest roads, West Dodge Road. This submittal will address the opportunities and challenges that informed the final electrical system solutions and schemes chosen by Murex.

4.2.1 Goals

The primary goals of Murex are to maximize safety, integrity, and sustainability. These concepts are used to create a cohesive, efficient design. These goals were selected for the following reasons:

SAFETY

To emphasize the role of the facility in the community and focus on patients, the design incorporates services for tornado refuge and shelter, maximizes infection control in design of the systems, and creates environments where medical services can be provided without fear of having any complications because of the systems designed and implemented throughout the building.

INTEGRITY

The team designed at a high caliber while maintaining cost efficacy. The integration of all systems was paramount to supply quality work to meet and surpass the needs of the patients and staff throughout the building.

SUSTAINABILITY

The electrical team's design focus is on using resources wisely and providing long-lasting quality. The decisions made on the project were energy efficient to meet the needs of the hospital and keep it running smoothly with the best case scenario life cycle cost, rather than to try and meet a standard like LEED just to get a plaque on the wall.

4.2.2 AEI Build Initiatives

The AEI Build Initiatives include eight areas of focus within the Architectural Engineering profession to aim to improve the design, maintenance, and construction of integrated buildings. The Murex design works to incorporate all of these through the goals set, and in all meetings members were reminded to keep these initiatives in mind while researching and developing the building systems and design.

4.2.3 Challenges

The overall project challenges were addressed by the electrical team. They are addressed throughout other sections, but brief summaries are provided below.

- ENCLOSURE: The enclosure will be all around the building, including the window pop outs for each patient room. For these windows, shading and daylighting technologies will be utilized to aid in the design challenge. The motorized Mechoshades and daylight sensors will work seamlessly together to provide optimal daylight to the occupants of the room, while still providing the patient the control to choose where their shades and light levels are at.

- SMART BUILDING: All of the systems throughout the building are compatible with each other. This includes the building monitoring system, security system, healthcare specific systems, lighting control systems, and mechanical controls. The building monitoring system can display any part of this which will be located at kiosks in lobby areas, as well as the home screen for each TV throughout the building.

  DISASTER RESPONSE PLAN: The electrical systems have been designed to keep power to the tornado shelters, as well as places like Operating Rooms, where the patients are in a high risk situation without the disaster occurring. Whether a loss of power comes from the local utility or a disaster, generators and Uninterruptible Power Systems will kick in depending on the event that occurs and allow all other systems to respond to the disasters and maximize the safety of those within the building.

4.2.4 Codes and Standards

Omaha has adopted the *2009 IECC*, and the electrical system design will be in compliance of the *2009 IECC* as a minimum, with the team going above and beyond in many cases to improve efficiency throughout the building. The following codes and standards have been used as an alternate path of compliance or in addition to the *2009 IECC*:

- *2007 ASHRAE 90.1*
- *2014 National Electrical Code*
- *2010 NFPA-72*
- *IESNA 10th edition handbook*

4.3.0 Design solutions

The solutions to the challenges listed above, as well as the building's electrical system will be addressed through the power generation and distribution systems, which are fully discussed in the following sections. In addition, controls, lighting, and other special systems including security will be outlined.

4.3.1 Power Generation

Omaha Public Power District (OPPD) will provide the electric service to the building and Metropolitan Utilities District (M.U.D) will provide the natural gas service. The electrical team analyzed the cost of serving the building's heating system with natural gas compared to electricity. The results are shown in the supporting documentation (link). The analysis shows that using natural gas for heating instead of electricity will reduce yearly heating costs by 75% and overall energy costs by 3%. The utility transformers will be located at the Southeast corner of the building at the entrance for Lower Level 5. There will be four services of 4000A each, and the building service will be a 480/277V, 3-phase, 4-wire feeder based on the building load described in the supporting documentation. The following sections describe additional power sources used for the project, including energy piles and the UPS.

4.3.1.1 Energy Piles

The energy piles will utilize geothermal energy which will reduce the electrical load in cooling mode. As the energy piles will be able to support part of the cooling tower load, the energy saved in return will allow the cooling tower to be a smaller size thus saving electrical energy.

4.3.1.2 Emergency Power

The building will be equipped with a UPS, discussed below, as well as four emergency generators. One will feed the critical power, one will feed the life safety power, and another will feed the equipment power, while the fourth one will be for redundancy. Their sizes will be 1250kW each. They will each have a 2500 gallon diesel storage tank located near it to provide 48 hours of run time in case of power loss or disaster. They will be attached to generator paralleling gear so that the loads that need to be served first are able to, as well as allowing all generators to synchronize before connecting to the system. This will prevent issues with sine waves being out of sync, which would put harmonics on the system. This would be a serious problem because there is a large amount of sensitive equipment being served on emergency power. Calculations for the generator are included in the supporting documents (link)

4.3.1.3 Uninterruptible Power System

The two options of battery backups and flywheels were discussed when considering the UPS designed for the Operating Rooms. The team decided to implement flywheels into the project. This was due to the flywheels having a better reliability, energy efficiency, and lower life-cycle costs. Some of the disadvantages of batteries would be battery acid neutralization and battery monitoring systems that would need to be implemented to make them effective and safe. Because of these factors, and the building already having several layers of redundancy incorporated into it, flywheels were decided to be a more feasible option. The flywheels will be located in the OR UPS room on Level 1 for convenient location near the Operating Rooms. The UPS will provide power to the OR loads while the generators are starting up, connected to the critical branch panels via an automatic transfer switch.

4.3.2 Power Distribution System

The power distribution system will be throughout the building, encompassing a multitude of different pieces of equipment. The service entrance will be at the Southeast corner of Lower Level 5, where the four services will enter. Almost all major electrical distribution equipment is located on this Lower Level 5 to effectively maximize space used and create a central location for the structural team to design around, instead of multiple smaller locations. This also allows for ease of access for maintenance purposes. Locating the electrical and mechanical equipment in the same vicinity allows for shorter piping, conduit, and ducts between equipment, which will save in costs for installation and materials.

Each main switchboard will break off into two primary distribution panels, each to serve one of the stacked electrical rooms, having a total of eight panels each, from Lower Level 5 to Level 2. There will also be secondary distribution panels on Level 3 fed from the primary distribution panels, that will feed power for Levels 3 and up.

Each electrical room will incorporate a high voltage and low voltage normal power panel, as well as a high and low voltage panel for critical, life safety, and equipment. From the A electrical rooms, two sub-panels, normal and a critical low voltage, will be fed to accommodate the patient rooms in the Southwest Corner of the building that otherwise could not be reached adequately because of voltage drop. These panels will be located out in the corridor, recessed into the wall and be dedicated to patient care.

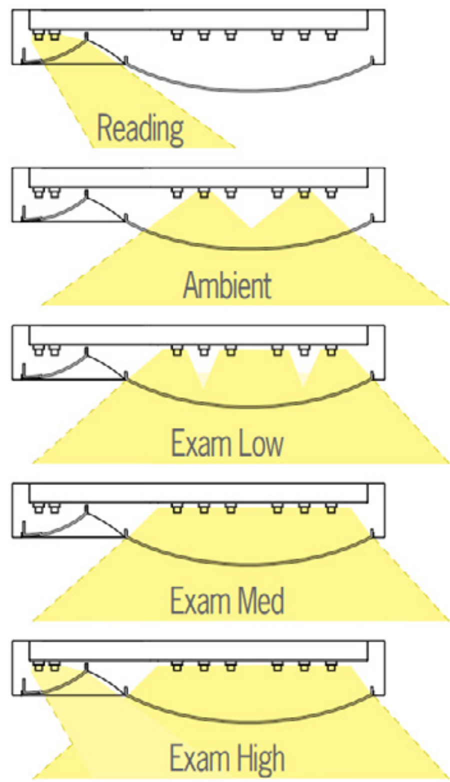
Each typical patient room will have two circuits, one normal and one critical. The normal circuit will feed half of the patient headboard receptacles, as well as convenience receptacles, while the critical circuit will only feed the other half of the patient headboard receptacles. Also out of the electrical rooms will be the isolated ground panels for each operating room. One normal and one critical panel will be present for each OR, and between the isolated ground transformers and the high voltage critical panel will be the UPS. Each operating room will have 36 dedicated receptacles, 18 with normal power and 18 with critical power.

4.3.3 Lighting and Controls

The lighting and control systems utilized throughout the facility will give consideration to human health and comfort, as well as lighting for clinical function within the constraints of the healthcare context.

4.3.3.1 Lighting Equipment

There will be a variety of fixtures used, all of which will be exclusively LED. Patient rooms will utilize the Visa Unity fixture which has multiple levels of illumination for reading, ambient, and three different levels of exam lighting. It has an amber LED night light to minimize disturbance to the patient's circadian rhythms, with a diffuse blue spectrum to minimize harshness on the patient's eyes. It comes with antimicrobial finishes on the interior and exterior surfaces, as well as a switching interface accessory available for the pillow speaker to enable patient control consolidated with TV controls and nurse call systems, among other things. It also features dimming to 1% which can be patient controlled with an override option for staff.



In the family area of each typical patient room, the Visa Serenity lamp with charging receptacle base has been chosen to match and create a family, with a nod to hospitality, creating a more comfortable atmosphere. It has 0-10V dimming, allowing for the 3000K lighting to adjust to whatever mood the family may feel. The dimmer is right on the luminaire base for ease of access. The USAI True Zero Connect Wall Wash with Color Select will be utilized as well which follows the cycle of daylight, helping patients adjust to life constantly inside by providing healthy lighting following the circadian rhythm from 2200K all the way up to 6000K in areas where patients are temporarily living. Kenall Medmaster Cleanscene graphic lightboxes will also be implemented in places of high patient stress which show moving colors or pictures directly above where the patient will be lying. Other standard troffers and downlights will be used throughout most other spaces that are sealed and contain UV light for cleaning where appropriate. For any fixtures that are in excess of 50 across the project, an attic stock for the drivers will be required for ease of replacement. The controls will be through Legrand's Digital Lighting Management System. Lighting Control Panels, daylight sensors, occupancy sensors, and personal controls, all connected by CAT5e cables, will be the main components. Motorized Mechoshades will also be utilized because they provide empowerment to patients.There will be lights connected to the normal, life safety, and critical branches. The life safety branch will have emergency egress lights through corridors, public waiting areas, and any other places needed to create a safe path of egress out of the building. On the critical branch will be any lights placed in operating rooms, critical procedure rooms, and elsewhere at the discretion of the hospital. All other lights will be on the normal branch.

4.3.3.2 Lighting for specific rooms

Each typical room type will be discussed and the lighting and control needs for each will be explained.

4.3.3.2.1 Corridors

The corridors will utilize direct/indirect lighting from the Cooper Corelite Divide-DWI-WD.

This fixture will limit glare and also be able to provide a multitude of light levels. This is important because during normal operation only about 20 footcandles are required, but if an emergency situation arises, the illuminance will need to be raised immediately to near 50 footcandles, especially in general corridors while at night as low as 5 footcandles will be acceptable. The fixture will be used throughout all corridors for consistency to the design, but in general and patient corridors, lower light levels will be maintained. The fixture will offer the flexibility to provide as low as 1702 lumens, while it can max out at 6849 lumens in an emergency, or sit at any one of four other levels in the middle during typical daytime operation.

4.3.3.2.2 Patient Rooms

Patient rooms will need a patient light, caregiver light, family light, task surface light, and in some cases a bathroom light. Shading and daylight controls will also be present in these rooms as most patient rooms are located along the exterior of the building. The typical patient rooms, as well as NICU, CCU, PICU, Fetal Care Units, and Hematology/Oncology Rooms fall under this category. The Visa Unity will provide patient and caregiver light. This fixture has a CRI of 93 which is very important in spaces such as the NICU, where jaundice, a yellowing of the skin and eyes, and cyanosis, a blueish purple tint to the skin, must be detected immediately. The reading light option also will be directed away from the baby's eyes, which are still extremely sensitive and need almost complete darkness to develop correctly, which also makes the amber night light option extremely valuable. The USAI True Zero Connect will be utilized as a wall wash in the general patient rooms on Level 1 and Lower Level 1. The Visa Serenity will provide the family light with simple control and charging access. The task surface light will be the H.E. Williams 1SF which provides uniform, glare-free illumination for caregivers. The Mechoshades will be in these rooms, which integrate seamlessly with the pillow switch and can create a full blackout and are antifungal and low maintenance. When the Mechoshades are not in use, daylight sensors in the room will regulate the light levels in the room through the controller in the LCP.

4.3.3.2.3 MRI Rooms

MRI Rooms are specialized in that they must contain all nonferrous materials so they will not react with the giant magnet in the room. The graphic lightbox will be implemented here directly above the machine to calm and soothe the patient. MedLux Color Changing COVE Lights are also to soothe and calm the patient, while they can be switched to 4000K white if necessary by the medical professionals. The nonferrous downlight LSQ60 from H.E. Williams will also be placed in a ring around the edge of the room that will be controlled from within the MRI control room. This fixture uses warm-dim technology to provide comfortable, warm, low-light levels for procedure lighting and provide crisper white for high light levels used for cleaning.

4.3.3.2.4 Procedure Rooms

This will include spaces such as x-ray rooms, and will have layered lighting. They will contain the same MedLux COVE Lights, but the more cost effective non-MRI version, dimmable to 1%. There will also be MedMaster downlights throughout the room to create the 30-40 footcandles necessary for cleaning, with all controls within the booth.

4.3.3.2.5 Medical supply and exam spaces

These spaces will be lit with 2x2 troffers. The Kenall MEIC22 with Indigo Clean technology will be implemented. This will provide for adequate lighting as well as constant disinfection of the air and surfaces. What makes Indigo Clean special is that it uses 405nm visible light rather than UV light, which is not harmful to patients or surfaces.

4.3.3.2.6 Operating Rooms

In Operating Rooms, the procedure boom lighting will be provided by the health professionals to match what they are used to and prefer. There will then be one or two rings of light fixtures around the operating table depending on the size of the operating room. The first ring will be the Kenall M4SEDIC22 which is a 2x2 troffer with switchable Indigo Clean disinfection for surgical suites, meaning that it is one piece, seam welded construction that is airtight without ventilation. If applicable, the second ring will be downlights, the LSQ60 fixture from H.E. Williams, but this instance will be 4000K without changing colors.

4.3.3.2.7 Public Areas

The aim of public areas, such as a family waiting area or lobby, is to have a soft, comfortable light. People in these areas could be receiving the best or worst possible news in these areas, so it is important to be able to provide something calming to both extremes. The BeveLED 5.0 with Warm Glow dimming by USAI will be utilized. The warm light reduces the stress hormone, cortisol, which makes it easier to relax and unwind.

4.3.3.2.8 Nurses Stations

The nurses stations will have a high general illumination with under cabinet task lighting. The general illumination will be from decorative downlights with dimming, presenting a humanistic touch and allowing the nurses to have the light level necessary to meet their needs. The task lights will be standard for undercabinet with an antimicrobial finish on them to help prevent germs from building up anywhere in this central environment.

4.3.3.2.9 Office/Conference

Office and conference rooms will feature suspended indirect lights in the center to provide ambient lighting for the room. In the conference rooms, there will be a ring of downlights around the outside of the room that will be dimmable, whether it be because only the indirect light is wanted, or for AV purposes if a presentation or video conference may be going on.

4.3.3.2.10 Dining Area

The dining area will provide a stress reduction, as well as accents to visually stimulate guests in the building who have probably been sitting in the same areas the entirety of the day otherwise. The general lighting will come from indirect linear pendants at 3500K that will create a welcoming environment and some contrast from what the accents will be. The accent lighting will be wall wash downlights to highlight the texture directly behind the seating areas, as well as Art Glass Dome Pendants that will hang directly over the tables.

4.4.0 Special Systems

A variety of special systems were used in the design and contribute to many aspects of the overall design. Not only do these systems help with the sustainability of the building, but they incorporate unique features that occupants will enjoy. Some of these features include a state of the art security system, building monitoring system, and a specialty healthcare controls system.

4.4.1 Security System

The Stanley Healthcare Hospital Security and Access Control Systems will be utilized throughout the building. This system includes electronic access control, intrusion and burglar alarms, manual and electronic security locking hardware, physical door hardware and locks, automatic sliding and revolving doors, video surveillance, and visitor management, among other things. The products are able to deploy and integrate with other industry 3rd party systems and devices, including the Lutron Lighting Controls, DGLogik DGLux5 System, and the Workflow Software Solutions, detailed below. The broad variety of products available allow the customization of a fully integrated facility and healthcare security management system. It also comes with a service and maintenance plan with repair services on demand, as well as training for the hospital personnel who will interact with it.

4.4.2 Building Monitoring System

A building monitoring system with real-time building performance data is installed to give occupants a better understanding of how the building operates. The system incorporated will be the DGLogik DGLux5 System as part of Acuity Brands.

This system allows for access to all data sources in a single unified workspace which can derive information from any database, iot device, or social media platform, among other things. It has an entirely drag and drop environment which allows for instant customization for which data sets are most important. It can be run in a web browser and on any mobile device. It is also very easy to follow and attracts the eye, so building occupants can understand what is going on

in the building and how they could be affecting it all. Either a full overview can be shown, or specifics about any particular control and its system, such as the HVAC application seen below.

This will be shown at a kiosk in each lobby, as well as being the start screen for all TVs throughout the facility. What will be shown in these public applications will be controlled from a centralized authoritative source within the hospital, as much information will be in this system that the public does not need access to, such as tracking of equipment and other patients, or security systems.

4.4.3 Specialty Healthcare Controls System

The Workflow Software Solutions created by Healthcare Control Systems will be utilized throughout the building. SSome of the key Workflow programs utilized by the electrical team will be ICUControl™, ORControl™, AssetControl™, CaseControl™, VantageED™, and VantageDI™.

Each of these has a Real Time Locating System to track doctors, nurses, patients, and equipment throughout the healthcare facility. The systems seamlessly coordinate with each other, whether it be between the ICU and OR departments, bed units, reducing phone calls and pages, which allow staff the opportunity to focus additional time and attention on their patients. The systems coordinate activities such as surgeries, and puts physicians, OR staff, patients, and dozens of other groups and departments across the facility on the same page at the same time. The status of rooms, procedures, patients, schedules, and critical equipment can be transparently viewed by all that need to know. There is also the flexibility for surgeons to request an open slot in the OR schedule, and the system constantly re-evaluates and modifies the schedule throughout the day, alerting parties when situations arise that could cause changes to their schedule. Also with the two Vantage systems, real-time access to critical logistics, information, and performance indicators are provided to improve speed, effectiveness, and responsiveness of the staff, via simple, interactive, customizable dashboards and alerts that are compatible with iOS and Android. It also provides real-time logistics that identify and eliminate errors and delays throughout a patient's time in the hospital.

4.4.4 Fire Alarm

The fire alarm control panel is located in the main electrical room. The fire alarm system has the capability of sounding a pre-recorded voice fire evacuation message. When a sprinkler flow device or detector is activated, the system is capable of flashing the strobes after the system has been silenced until the system reset has occurred. The system is also capable of shutting down mechanical equipment during a general alarm, while monitoring the emergency loads. triggering the path of egress lights.

4.5.0 Integration

4.5.1 Integrated Project Delivery

For this project, Murex utilized the Integrated Project Delivery (IPD) Method. This method allowed for the electrical design to be integrated with the other disciplines during the entire design phase of the project. This delivery method worked well as the design called for interdisciplinary coordination, such as the energy piles and equipment locations due to space limitations. IPD allowed for quick response times to constant design changes from all disciplines. By using this method, the electrical team was able to design Lower Level 5 with the mechanical team to properly locate all electrical and mechanical equipment. Having the contractors on board during the design process is extremely valuable as feasibility questions came into play with the project site as well as budget concerns so that value engineering options can be immediately discussed and implemented as early in the process as possible.

4.5.2 Structural Integration

Collaboration between the structural and electrical teams was present throughout the design process. The use of IPD streamlined the application of new ideas such as equipment placement with the voided slabs. The structural team found this new method during research and brought forward the idea, which meant a few compromises needed to be made elsewhere. With the voided slab, Murex is able to save money because there is physically less material, and the voids also allow electrical conduits to run through it in certain cases, saving money on conduit and conductors throughout the building. Also the location for the tornado refuge room was chosen carefully to allow for easy access to the electrical power.

4.5.3 Mechanical Integration

The mechanical and electrical teams agreed that a centralized location for all major equipment was the best way to maximize tenant space. Major equipment is located on Lower Level 5. The electrical and mechanical teams coordinated the equipment carefully to ensure that enough space and clearance was provided. The coordination of equipment locations on each patient care floor was also very important. Two electrical rooms are utilized, one plan west and one in the center of the plan.

4.6.0 Conclusion

Murex exemplified our goals of safety, integrity, and sustainability throughout the project. The electrical design also met their independent goals of providing the safest building possible as well as allowing for a comfortable and personalized experience for all who enter the building. All of these main goals were supported by the sub goals of having highly efficient systems, reliability, cost effective choices, as well as patient control and comfort. In achieving all of these goals, we have in turn fulfilled the challenge put forth by the owner as well as the AEI Student Design Competition Challenges.

DGLux5

Modern Toolsets. One Workspace. Data-Driven. All Yours.

DGLux5, our "drag & drop" rapid application development and visualization platform enables individuals and teams to design real time, data driven applications and dashboards without ever writing a single line of code. It maximizes analysis efficiency and enables faster communication through real time, data driven dashboards for web, desktop and mobile devices. Significantly reduce time and money in project design, creation and deployment with a modern platform that everybody loves, DGLux5.

Link Various Data

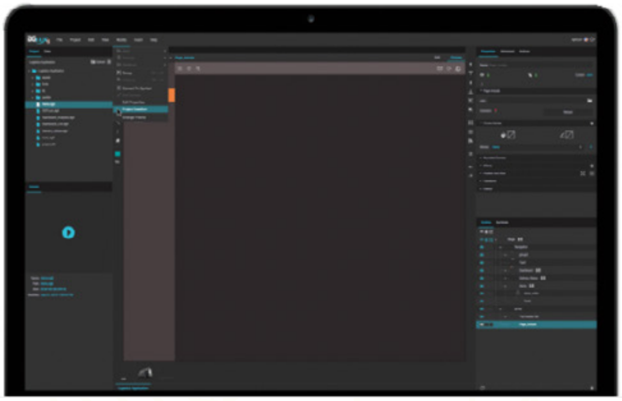
Gain access to all your data sources in a single, unified workspace. Derive information from any database, iot device, social media platform, etc.

Control & Command Data

Revolutionizing the way we build applications through visual programming, DGLux provides the tools for controlling & commanding your data!

Drag & Drop Data Binding

The data-to-property and property-to-property binding flexibility within DGLux5 is amazing but having a full drag and drop environment that drives that flexibility is absolutely stunning.



Client-Side Technology

DGLux runs in the browser, does not tax the CPU of your server and saves resources for your server to focus on collecting and analyzing data.

Mobile Responsive

Intelligent scaling with responsive layout in DGLux5 ensures that every user interface is automatically optimized for any screen size to ensure the optimal viewer experience on any mobile device.

Visual Programming Technology

Create logic sequences within our advanced, visual programming User Interface...without having to write any script!

Create Personalized Interaction

Create personalized interaction by adding behaviors to any object using the "Record State" feature which allows you to change parameters and automatically save the recorded changes as behaviors. This enables you to execute commands through any possible user interaction, creating unique, sophisticated interfaces and experiences.

Set Mouse Gestures

To build interactive applications, DGLux allows you to add behaviors to any objects interaction a user can make such as click, double click, roll over, rollover & out, mouse down, mouse up, click on, click off, load complete or custom triggers for a mix of interactions.

Set Touch Screen Gestures

DGLux enables you to build interactive mobile applications with support for all touch screen gestures such as swipe, rotate, pinch, spread, two finger tap and scroll

Flexible Deployment

DGLux5 offers multiple deployment options, support on multiple mobile platforms, resolution independence and a client-side architecture.

Customize Charts & Graphs

To display your data, DGLux offers many different customizable column charts, bar charts, line charts, area charts, pie charts, radar charts, dynamic charts, and scatter charts to best represent your systems.

Stunning Graphics Library & Widgets

You aren't starting from scratch. DGLux provides graphical assets to get you started such as assorted animated widgets, background themes, patterns, effects, 3D equipment, assorted icons, glass effects and much more!

Data Connections Available

TRIDIUM | DISTECH CONTROLS | Schneider Electric | twitter | facebook | MQTT

Healthcare Control Systems

Powerful Technology - WorkflowControl™

"Our time-to-money was less than 6 months from the start of the HCS workflow control project to the realization of hard dollar benefits"

Dr. Robert Bonar
President and Chief Executive Officer
Dell Children's Medical Center of Central Texas

Facility-wide coordination in real-time

Effortlessly change your schedule on-the-fly circumventing cancellations and delays across all departments.

Top and bottom line financial growth

Improve surgeon attraction, case volumes, and market share while simultaneously reducing overtime

OpenTableOR™

Allows surgeons and their offices to effortlessly fill your open OR slots via their cell phones.

Add-a-Surgeon™

Aggregates wasted OR and staff time scattered throughout your day into blocks salable to splitters and new surgeons.

No training needed

System configured to match your existing and future workflows making it as easy to use as an ATM.

Complements your clinical systems

Fully compatible with your existing clinical systems Epic, Meditech, Cerner, Optum-Picis, VistA

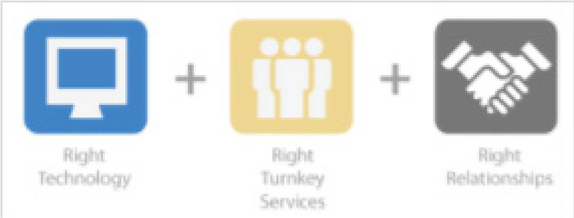
Available on every device you use every day - Windows, Mac, Android, iOS, smart phones - fully HIPAA compliant.

Healthcare Control Systems

Powerful Technology - WorkflowControl™

Our turnkey approach makes all the difference

HCS does not just sell great technology. We are successful because we combine the right technology with the right turnkey services and the right frontline hospital relationship.



Right Technology

HCS systems integrate five functional areas crucial to achieving operational control of your workflow:

- **real-time tracking** of all statuses, patients, staff, and critical equipment
- **dynamic scheduling** and rescheduling as your workday unfolds with all changes immediately processed
- **information transparency** requiring virtually no data input and displaying all information on any workstation or personal device throughout your facility and beyond
- **proactive alerting** of any event or activity that is likely to cause an upcoming delay
- **reconfigurability** of the system to immediately address any change in your hospital's workflow, market condition, regulation, or surgeon need

Right Turnkey Services

Ongoing personnel services offered by HCS to their clients include:

- On-site **Continuous Workflow Improvement (CWI℠)** to eliminate inefficiencies that frustrate your front-line physicians and staff
- **Centralized Monitoring and Remediation (CMR℠)** to remotely sustain process improvements and benefits 24/7
- The ability to reconfigure our systems and implement workflow control improvements in hours and days, not weeks or months

Right Relationships

- Annual **fixed fee contracts** avoid piece-meal budgeting, approvals, and delays
- Regular **on-site presence** promotes dialog/understanding/trust with front line physicians and staff

MechoNet™ Wireless Daylight Sensor (WDS) and Controller

No wires. No batteries. No complications.

Room-level or total building automation with daylight control on MechoNet

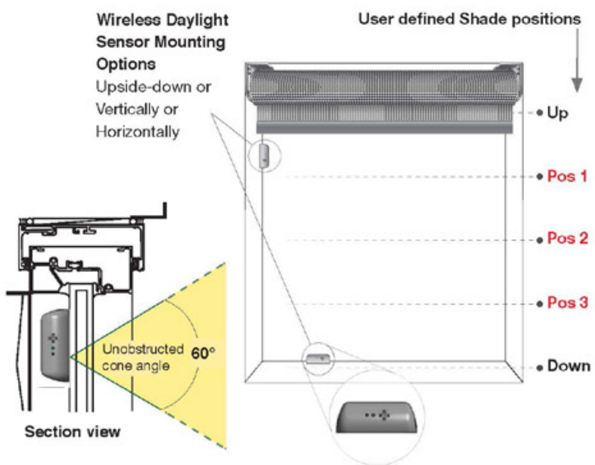
MechoSystems' Wireless Daylight Sensor with EnOcean® wireless technology monitors daylight coming through the curtainwall without the clutter and hassle of managing cables and batteries. This sustainable solution harvests energy from the sun to power its ultra-low energy internal electronics. The controller sits on the bi-directional MechoNet communication network.

Features and benefits:

- EnOcean wireless technology.
- Controller automates 2, 3, 4 or 5 customizable stop positions.
- Each controller manages up to 16 EnOcean devices.
- Form factor: sensor nests against the mullion and is less obtrusive than a round sensor.
- Monitors daylight coming through the curtainwall.
- Sensor supports a photopic response which is sensitive to human comfort.
- Sensor requires no wires, no batteries.
- WDS is solar-powered photovoltaic (PV).
- WDS automatically converts light to energy for power.
- WDS is able to withstand millions of recharges.
- The sensor has ultra-low power requirements with reliable EnOcean-based, 2-way wireless messaging.
- Peel-and-stick sensor mounts horizontally, vertically, and upside-down on the mullion, without any screws.
- The sensor is available in white, grey, and black.
- The controller supports a night mode position allowing customized shade positions when lux levels dip below a predefined value.
- Override capability with timed automation mode return.

Applications:

- Automated shade positioning with user defined intermediate stop points based on adjustable brightness thresholds.
- Integrated window-covering, lighting, and HVAC control.
- Scalable daylight measuring of motorized window coverings to optimize comfort, views, and energy conservation.
- Stand alone system or relays sensor data up to SolarTrac® to provide local brightness control in support of whole-building automation.
- Daylight harvesting and code compliance. (e.g. LEED®, ASHRAE 90.1-2010, Title 24-2013, IECC2012, IgCC 2012)
- Targets new construction, renovation or retrofit applications for home or building control.



MechoSystems Design with light.® enocean®

Winner 2016
NeoCon® Innovation
HiP Honoree
WCMA, New Style Concept

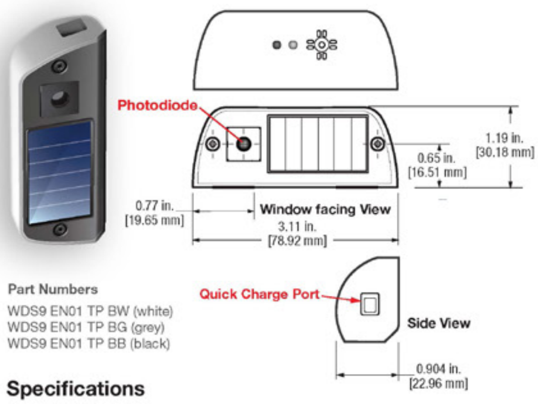
Over

MechoNet™ Wireless Daylight Sensor (WDS) and Controller

Wireless Daylight Sensor

Mounts in any direction, unobtrusively, on the mullion

Dimensions



Part Numbers

WDS9 EN01 TP BW (white)
WDS9 EN01 TP BG (grey)
WDS9 EN01 TP BB (black)

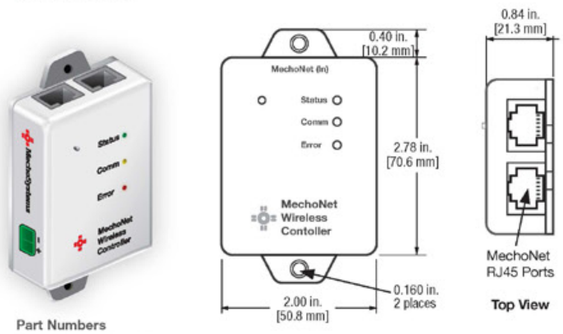
Specifications

Size	3.1 in. L x 1.2 in. H x 0.9 in. D
Color	White, Gray, Black
Power	Low light solar power (PV)
Wiring	Wireless
Frequency	902 MHz, EnOcean
EnOcean Equipment Profile	A5-06-04 For Curtainwall Brightness Sensor
Wireless Range*	Maximum 80 ft. (24 m) unobstructed
Certifications	FCC part 15 Class B Compliant
Temperature	32–140°F (0–60°C)
Photosensor	Daylight spectrum, photopic
Sensitivity	0–65 klux
Photosensor FOV	Horizontal: 60 degree cone angle Up: 30 degrees; Down: 30 degrees

MechoNet Wireless Controller

Mounts out of sight

Dimensions

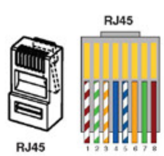


Part Numbers

MWC9 EN01 PP WH (pre-programmed)
MWC9 EN01 TP WH

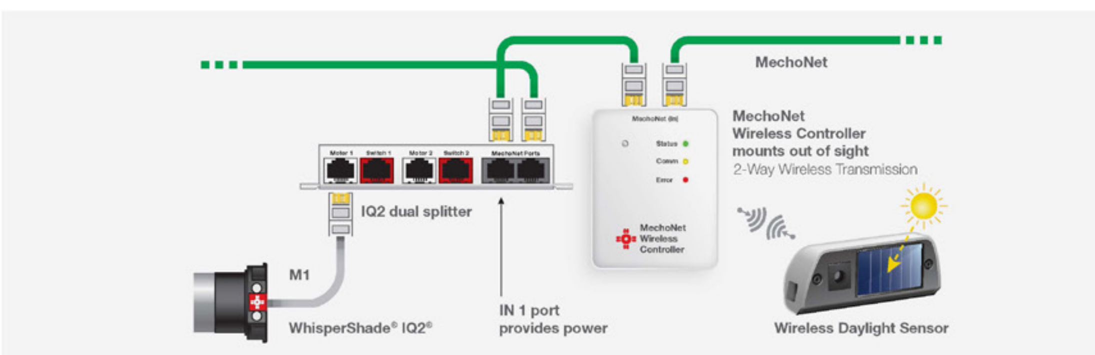
Specifications

Size	3.6 in. L x 2.4 in. H x 0.9 in. D
Color	White
Power	12–28 VDC, 100 mA, powered by MechoNet or separate power supply
Wiring	MechoNet: Cat-5/6. RJ45, 4000 ft. (1,219 m) total. 250 devices max.
Frequency	902 MHz, EnOcean
Wireless Range*	Maximum 80 ft. (24 m) unobstructed
Certifications	FCC part 15 Class B Compliant
Controls	Up to 16 Sensors or other EnOcean devices



CAT5/6 USOC Crimp		
Pin 1	Brown/White	MechoNet—Net A (NET A)
Pin 2	Green/White	Power—Motor/Controller (PWR)
Pin 3	Orange/White	Common (COM)
Pin 4	Blue	Power—Bus Supply (V+)
Pin 5	Blue/White	Common (COM)
Pin 6	Orange	Power—Bus Supply (V+)
Pin 7	Green	Common (COM)
Pin 8	Brown	MechoNet—Net B (NET B)

* Wireless signals may be impacted by metal columns, mullions, or other structures typically used in and around the curtainwall. As such, the Wireless Rocker Switch should be located as close as possible to the MechoNet Wireless Controller. For optimal performance, up to 25 ft. (8 m) is the recommended range.



⚠ Make sure the mounting location does not enable building and glazing features like overhangs, mullions, louvers, or frit to obstruct or cast shadows on the sensor's field of view.

MechoSystems
Design with light®

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W: mechosystems.com
E: marketinglic@mechosystems.com

@mechosystems

L10279.0517

Wireless Self-Powered Rocker Switch

Integrates with MechoSystems' daylighting control

Utilizing the reliable EnOcean® wireless communication protocol, this switch operates any MechoNet™ connected motorized roller shade via the MechoNet Wireless Controller (MWC).

For intelligent WhisperShade® IQ2® Electronic Drive Units, this is as simple as adding the MWC to the bus line and pairing the switch to a channel.
For other motor types, the MWC communicates directly with other MechoNet controllers such as the IQ/MLC2 or MNI.

This Decora single rocker style switch enables the shade to open, close, or stop on command at any intermediate position simply by pressing the button while the shade is moving.

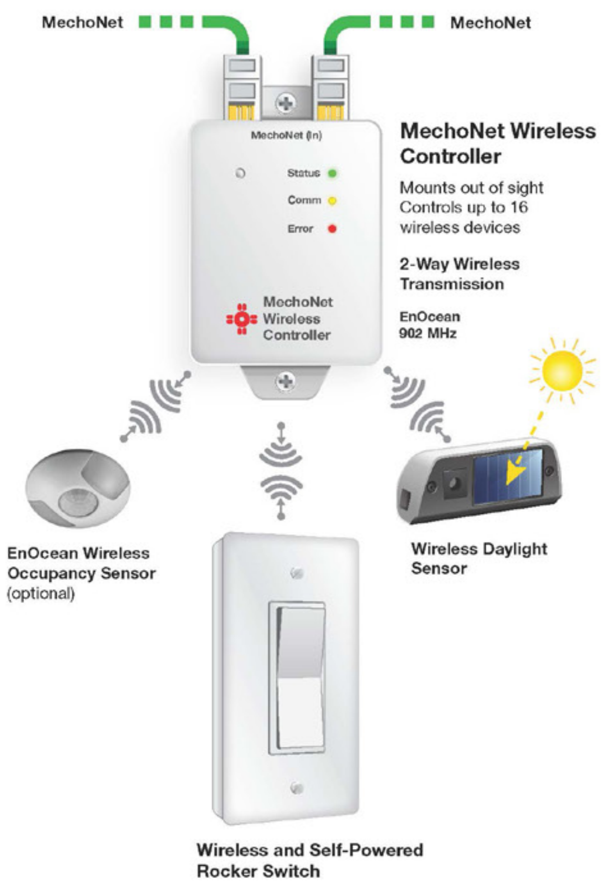
Pressing the rocker pad provides kinetic energy to transmit the signal with no other power requirement.

Features and benefits:

- Zero power consumption.
- Zero external power required.
- EnOcean wireless communication.
- Zero charge time to operate.
- No wires. No batteries.
- Wireless technology supports simplified daylight harvesting and manual override options.
- Rocker-style up/down/stop switching.
- Convenient multi-location (3- or 4-way) switching.
- Fits a standard single-gang j-box or can be surface mounted, and includes a Decora faceplate.

Applications:

- Each wireless switch can be placed anywhere within range of an MWC.
- Remote switch is typically surface mounted on a wall with screws or industrial tape.
- Ideal for retrofits and new construction.
- Switch can also be used in a standard wallbox or as a wireless handheld remote.



MechoSystems
Design with light®
enocean®

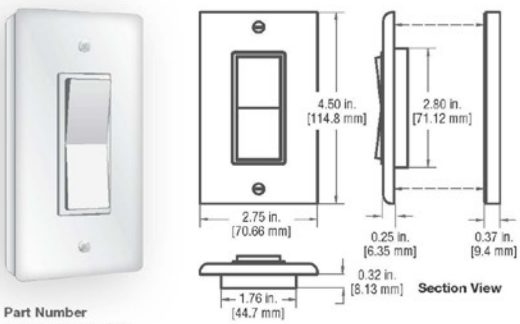
Over

Wireless Self-Powered Rocker Switch

Wireless Self-Powered Rocker Switch

Surface mounted or recessed

Dimentions



Part Number
ESWX-EN09_PC-WH

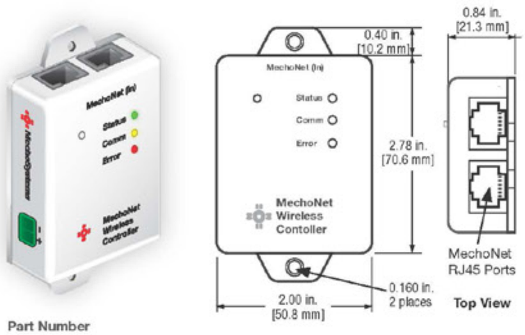
Specifications

Range	50–150 ft.
Frequency	902 MHz
Power Supply	Self-generated when switch is pressed
Memory	Stores up to 20 transmitter IDs
Transmission Interval	Touch
Frequency	902 MHz, EnOcean
Transmission Time	< 30 milliseconds
Transmissions	2 packets per press or release
Mechanical Cycles	> 50,000
Device Address	Unique from factory
Output Channels	Only limited by number of receivers in range
Usage	Indoors only
Operating Temperature Range	32–122°F (0–50°C)
Radio Certification	FCC Certified for Wireless Communication (U.S.), I.C. Certified (Canada) FCC ID: SZV-STM300U IC: 5713A-STM300U
Rockers	WSS0S-S9: 1 rocker, 2 pushbuttons
Dimensions	2.75 in. W x 4.50 in. H x 0.32 in. D

MechoNet Wireless Controller

Mounts out of sight

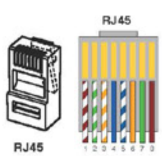
Dimentions



Part Number
MWC9 EN01 TP WH

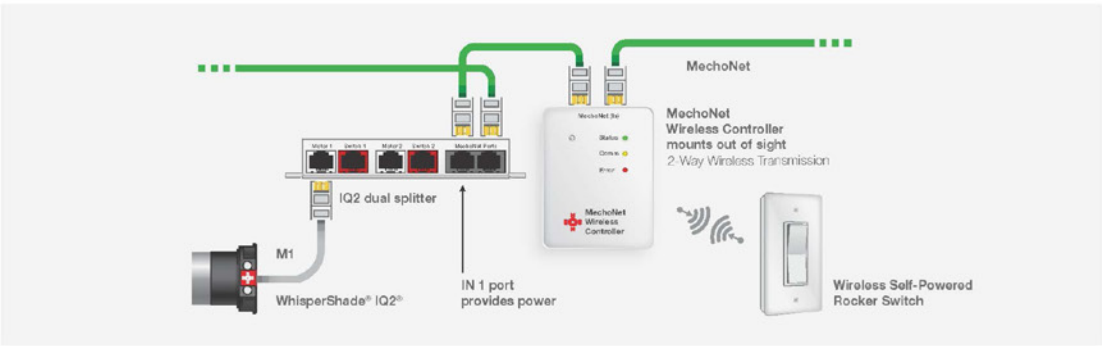
Specifications

Size	3.6 in. L x 2.4 in. H x 0.9 in. D
Color	White
Power	12–28 VDC, 100 mA, powered by MechoNet or separate power supply
Wiring	MechoNet: Cat-5/6. RJ45, 4000 ft. (1,219 m) total. 250 devices max.
Frequency	902 MHz, EnOcean
Wireless Range*	Maximum 80 ft. (24 m) unobstructed
Certifications	FCC part 15 Class B Compliant
Controls	Up to 16 Sensors or other EnOcean devices



CAT5/6 USOC Crimp		
Pin 1	Brown/White	MechoNet—Net A (NET A)
Pin 2	Green/White	Power—Motor/Controller (PWR)
Pin 3	Orange/White	Common (COM)
Pin 4	Blue	Power—Bus Supply (V+)
Pin 5	Blue/White	Common (COM)
Pin 6	Orange	Power—Bus Supply (V+)
Pin 7	Green	Common (COM)
Pin 8	Brown	MechoNet—Net B (NET B)

* Wireless signals may be impacted by metal columns, mullions, or other structures typically used in and around the curtainwall. As such, the Wireless Rocker Switch should be located as close as possible to the MechoNet Wireless Controller. For optimal performance, up to 25 ft. (8 m) is the recommended range.



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L10262.0317

Cost Comparison of Electricity vs. Natural Gas

	Electricity		Natural Gas	
Price of	$0.09	kWh	$0.66	CCF
Building heating load	6381711	kBTU	6381711	kBTU
Building heating load	$1,870,294.87	kWh	$62,565.78	CCF
Yearly heating cost	$162,341.59		$41,293.42	
Money saved	$121,048.18			
Yearly heating savings	75%			
Building energy load	$48,862,418.00	kBTU		
Yearly energy cost	$4,241,257.88			
Yearly energy savings	3%			

Emergency System Sizing Calculation

ENTIRE BUILDING			460000	SF		
		LIGHTING	1	VA/SF	460	kVA
		HVAC	5	VA/SF	2300	kVA
5	ROOMS	XRAY	37500	VA/XRAY	187.5	kVA
2	ROOMS	MRI	20100	VA/MRI	40.2	kVA
12	ROOMS	OR	3240	VA/OR	38.88	kVA
3	ELEVATORS	ELEV	18800	VA/ELEV	56.4	kVA
235	ROOMS	PT ROOM!	540	VA/ROOM	126.9	kVA
				Total kVA	3209.88	kVA
				(3) Generators at 1250 kW each		

Demand Sizing Calculation

ENTIRE BUILDING			460000	SF		
KITCHEN			6604	SF		
		LIGHTING	3	VA/SF	1380	kVA
		HVAC	12	VA/SF	5520	kVA
		RECEP	5	VA/SF	2300	kVA
		KITCHEN	8	VA/SF	52.832	kVA
5	ROOMS	XRAY	37500	VA/XRAY	187.5	kVA
2	ROOMS	MRI	20100	VA/MRI	40.2	kVA
12	ROOMS	OR	6480	VA/OR	77.76	kVA
12	ELEVATOI	ELEV	18800	VA/ELEV	225.6	kVA
235	ROOMS	PT ROOMS	1440	VA/ROOM	338.4	kVA
				Total kVA	10122	kVA
				Total A	12175	A
				Safety	125	%
				Total Load	15219.03	A
				(4) Services at 4000A each		

Fault Current Calculations

NAME	%Z	FEEDER LENGTH	*F* FACTOR	*M* MULTIPLIER	ISC(A)
XFMR	3.5			28.57	85911
MSN		75	0.479	0.676	58087
DPNA1		237	1.024	0.494	28699
2NHA		75	0.515	0.66	18944
T2NA	1.2	10	0.143	0.875	16571
2NLA		10	2.204	0.312	11934
2NLA-1		110	2.29	0.304	3628

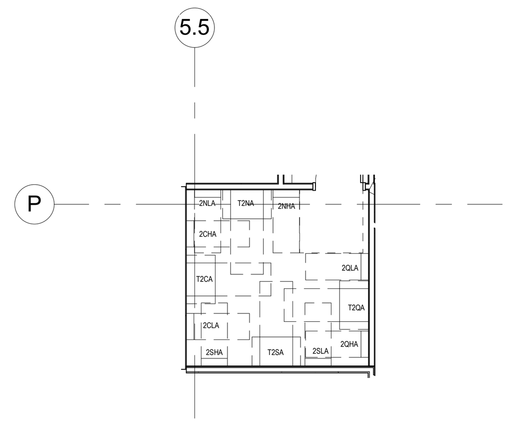
Voltage Drop Calculation

From	To	Amps	Wire	Ground	Length	Voltage	Voltage Drop	% VD
MSA	DPNA2	1200	(3) 4#600	#3/0	335	480	3.01	0.63%
DPNA2	6NHA	225	4#4/0	#4	55	480	0.26	0.05%
6NHA	6NLA	225	4#4/0	#4	10	208	0.048	0.02%
6NLA	Branch	12	2#12	#12	120	120	2.29	1.91%
					Total Feeders Voltage Drop			0.70%
					Branch Circuit Voltage Drop			1.91%
					Total Voltage Drop			2.61%

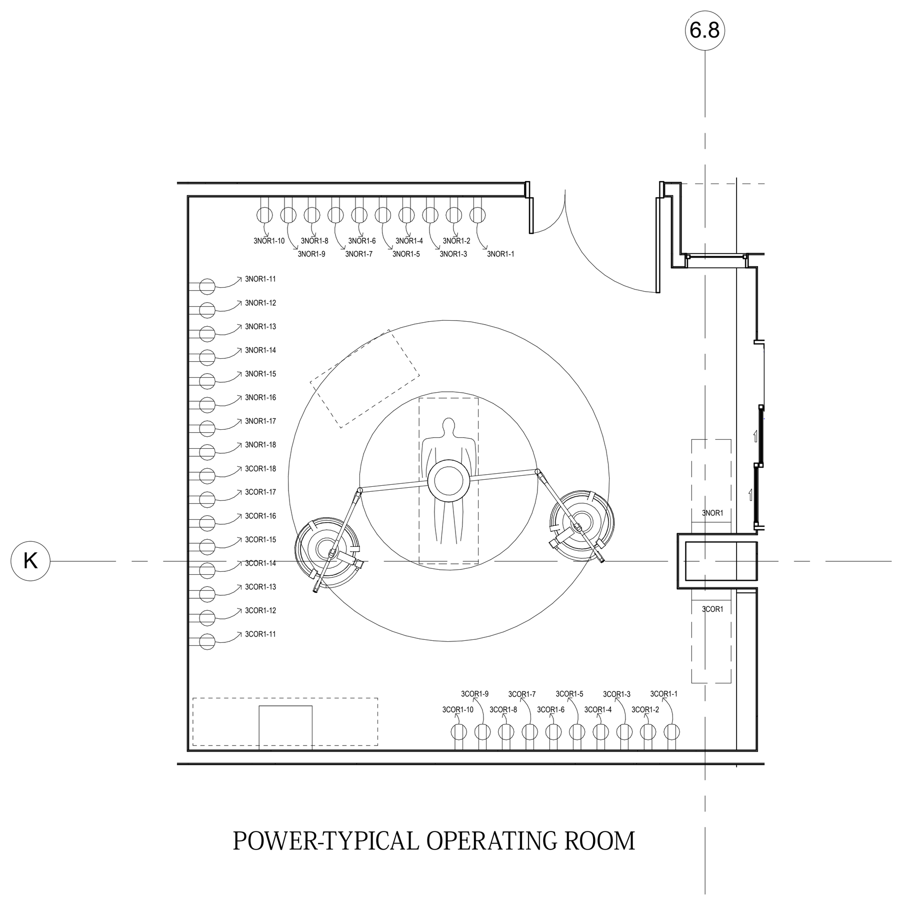
This voltage drop calculation follows the longest wire path throughout the building, representing worst case scenario. The total feeder voltage drop is at 0.70% which is less than the allowable 2% and the branch circuit voltage drop is 1.91% which is less than the 3% allowable. As such, the overall voltage drop is 2.61% which is less than the allowable 5%.

Mechanical Equipment Feeder Schedule

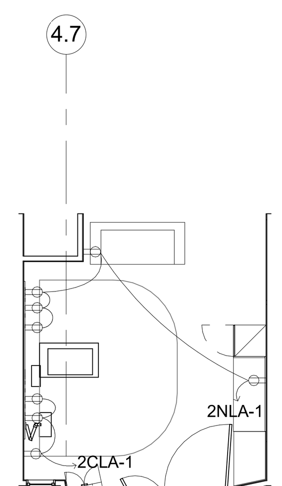
			Disconnect		
Designation	Volt	Phase	Type	Size	Poles
AHU-1	480	3	Heavy Duty	100	3
AHU-2	480	3	Heavy Duty	60	3
AHU-3	480	3	Heavy Duty	100	3
AHU-4	480	3	Heavy Duty	60	3
AHU-5	480	3	Heavy Duty	30	3
AHU-6	480	3	Heavy Duty	30	3
AHU-7	480	3	Heavy Duty	60	3
AHU-8	480	3	Heavy Duty	100	3
AHU-9	480	3	Heavy Duty	30	3
AHU-10	480	3	Heavy Duty	30	3
AHU-11	480	3	Heavy Duty	60	3
AHU-12	480	3	Heavy Duty	60	3
AHU-13	480	3	Heavy Duty	30	3
AHU-14	480	3	Heavy Duty	60	3
AHU-15	480	3	Heavy Duty	60	3
AHU-16	480	3	Heavy Duty	30	3
AHU-17	480	3	Heavy Duty	30	3
AHU-18	480	3	Heavy Duty	30	3
AHU-19	480	3	Heavy Duty	30	3
AHU-20	480	3	Heavy Duty	30	3
AHU-21	480	3	Heavy Duty	60	3
AHU-22	480	3	Heavy Duty	30	3
AHU-23	480	3	Heavy Duty	60	3
AHU-24	480	3	Heavy Duty	60	3
AHU-F1	480	3	Heavy Duty	60	3
AHU-F2	480	3	Heavy Duty	60	3
AHU-F3	480	3	Heavy Duty	60	3
CH-1	480	3	Heavy Duty	1200	3
CH-2	480	3	Heavy Duty	1200	3
BLR1-1	480	3	Heavy Duty	60	3
BLR1-2	480	3	Heavy Duty	60	3
BLR2-1	120	1	Motor Rated Switch	30	1
BLR2-2	120	1	Motor Rated Switch	30	1
BLR2-3	120	1	Motor Rated Switch	30	1
BLR2-4	120	1	Motor Rated Switch	30	1
CT-1	480	3	Heavy Duty	100	3



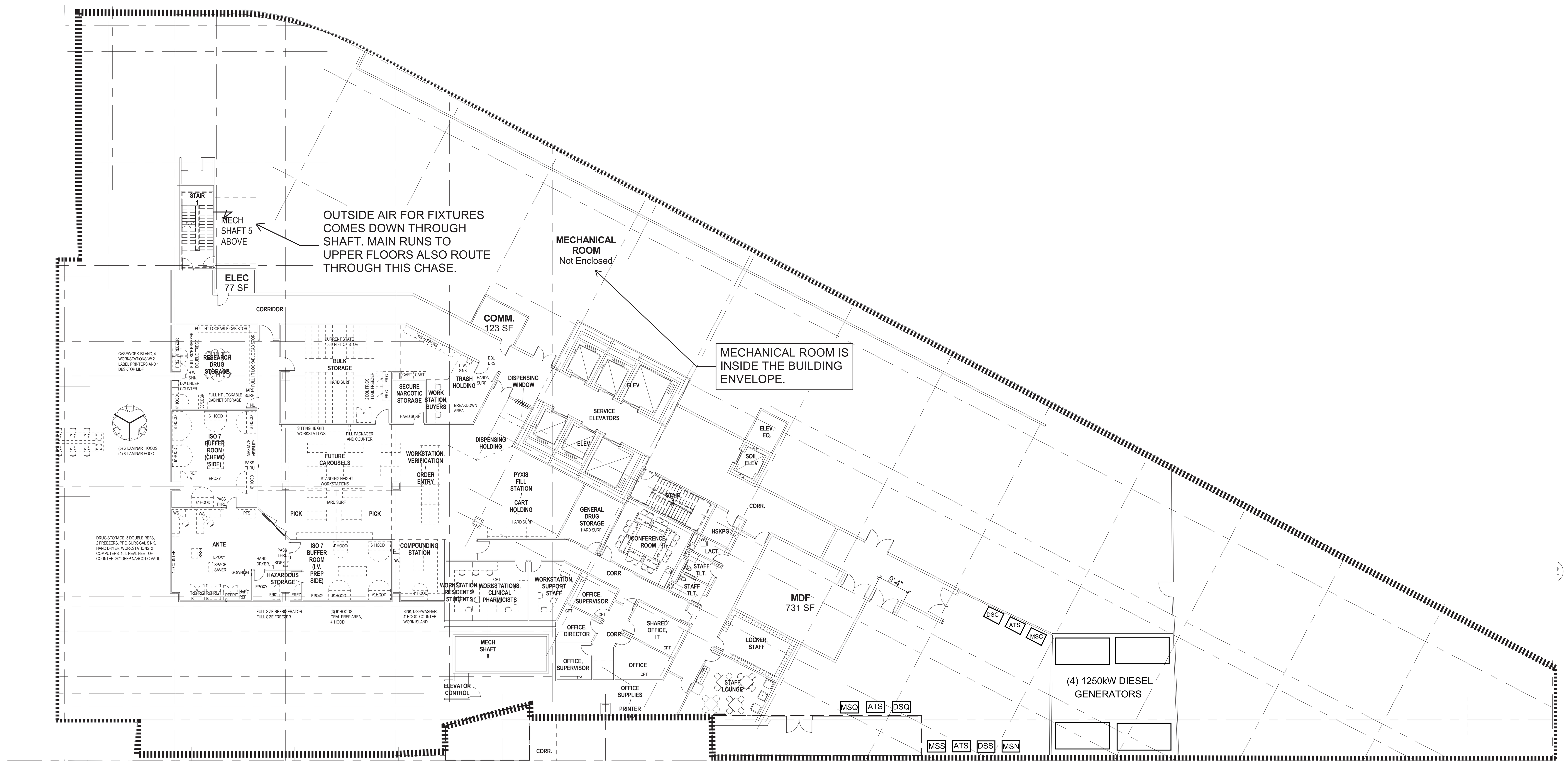
POWER-TYPICAL ELECTRIC ROOM



POWER-TYPICAL OPERATING ROOM



POWER-TYPICAL PATIENT ROOM



POWER LOWER LEVEL 5

(4) PAD MOUNTED 2500kVA UTILITY TRANSFORMERS

MUREX
EST 2017-18

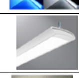
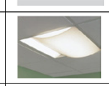
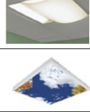
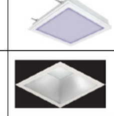
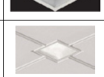
PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
ENLARGED ELECTRICAL PLAN

E-201

Lighting Control										
Space Type	LPD (W/SF)	a	b	c	d	e	f	g	h	i
Conferece Room	1.23	REQ	ADD1	ADD1	REQ	REQ	REQ	-	REQ	-
	Conference rooms will have local controls near each door, partial auto on and auto full off. Bi level lighting will come from dimming controls for the outer ring of lights. Daylighting is null.									
Corridor: in a hospital	0.99	REQ	-	-	-	REQ	REQ	ADD2	ADD2	ADD2
	Corridors will have local controls and auto partial off. Daylighting is null in this application. Daylighting is null.									
Dining Area: cafeteria	0.65	REQ	ADD1	ADD1	REQ	REQ	REQ	-	ADD2	ADD2
	The cafeteria will have local controls, partial auto on, and scheduled shutoff. Daylighting will be present at the north lighting, which will be dimmable, fulfilling the bi level requirements.									
Electrical/Mechanical Room	0.42	REQ	-	-	-	REQ	REQ	-	-	-
	Electrical and mechanical rooms will have local controls at each entrance. There will be no auto on or off because of life safety reasons. Daylighting is null.									
Locker Room	0.75	REQ	ADD1	ADD1	REQ	REQ	REQ	-	REQ	-
	Locker rooms will have local controls at the entrance, partial auto on and automatic full off. Bi level lighting will be implemented with every other fixture being switched because of the partial on application. Daylighting is null.									
Lounge/Break: healthcare	0.92	REQ	ADD1	ADD1	REQ	REQ	REQ	-	REQ	-
	Break rooms will have local controls at the entrance, auto partial on and automatic full off. Bi level lighting will be implemented with every other fixture being switched because of the partial on application. Daylighitng is null.									
Office: enclosed <250SF	1.11	REQ	ADD1	ADD1	REQ	REQ	REQ	-	REQ	-
	Offices will have local controls at each entrance. Lower Level 3 offices on the north exposure of the building will be manual on, while all other offices will be auto on. Auto off will be implemented. Half of the fixtures in the Lower Level 3 offices will be dimmable for daylighting purposes, fulfilling bi level requirements.									
Pharmacy Area	1.68	REQ	ADD1	ADD1	REQ	REQ	REQ	-	ADD2	ADD2
	Pharmacy areas will have local controls, auto partial on and auto full off. All fixtures will be dimmable to meet bi level requirements. Daylighting is null.									
Restroom: other	0.98	REQ	-	-	-	REQ	REQ	-	REQ	-
	Restrooms will have local controls at the entrance and auto off, making them manual on. Daylighting is null.									
Healthcare Facility: exam room	1.66	REQ	-	-	REQ	REQ	REQ	-	ADD2	ADD2
	Exam rooms will have local controls at the entrance and auto off. They will be manual on with two contacts in the controller to meet bi level requirements. Daylighting is null.									
Healthcare Facility: imaging room	1.51	REQ	-	-	REQ	-	-	-	ADD2	ADD2
	Imaging rooms will have local controls at the entrance and auto off. They will be manual on with two contacts in the controller to meet bi level requirements. Daylighting is not required.									
Healthcare Facility: supply room	0.74	REQ	ADD1	ADD1	-	REQ	REQ	-	REQ	-
	Supply rooms will have local controls at the entrance, auto partial on, and auto off. From the auto partial on, bi level requirements will be met. Daylighting is null.									
Healthcare Facility: nurse's station	0.71	REQ	-	-	REQ	REQ	REQ	-	ADD2	ADD2
	Nurses stations will have local controls and auto off. Bi level requirements will be met by all fixtures having dimming capablities. Daylighting is null.									
Healthcare Facility: operating room	2.48	REQ	-	-	REQ	-	-	-	ADD2	ADD2
	Operating rooms will have local controls at the entrance and auto off. They will be manual on with two contacts in the controller to meet bi level requirements. Daylighting is not required.									
Healthcare Facility: patient room	0.62	REQ	-	-	REQ	REQ	REQ	-	ADD2	ADD2
	Patient rooms will have local controls at the entrance, on the pillow speaker, and in the family area, which will have a dimmable fixture and auto off. Bi level will come from the patient light and the wall wash, where only the part of the wall wash will come on automatically. Only the family area fixture will be affected by daylighting, and as such it has manual and automatic dimming capabilities.									
Healthcare Facility: recovery room	1.15	REQ	-	-	REQ	REQ	REQ	-	ADD2	ADD2
	Recover rooms will have local controls at the entrance and auto off. Every other light will be switched to create bi level switching with manual on. Daylighting is null.									

a: Local Control
b: Restricted to Manual ON
c: Restricted to Partial Automatic ON
d: Bilevel Lighting Control
e: Automatic Daylight Responsive Controls for Sidelighting
f: Automatic Daylight Responsive Controls for Toplighting
g: Automatic Partial OFF
h: Automatic Full OFF
i: Scheduled Shutoff

Lighting Fixture Schedule						
Designation	Image	Manufacturer	Model	Lamps	Volt	Watts
CD1		KENALL	M4DL6 R 12L 40K8 M CS T RIS6 120 DIM1	LED	120	12
CD2		EATON	340 EU6B 3040 20 9030DTW 6LBW1LI CF	LED	120	42
LC1		MEDLUX	MALS-24.0 FK MCL RGB 72	LED	120	71
LC2		MEDLUX	MALS-20.0 NK MCL RGB 48	LED	120	60
LP1		EATON	CTA F 7525 30L835 1D UNV STD W AC 4	LED	120	23
RF1		VISA	TF1934 L25A19 120V CVBL ORB AMC DIM NGT	LED	120	25
RS1		H.E. WILLIAMS	1SF 4 L24/840 DMA AMW DRV 120V	LED	120	29
RW1		EATON	DWI WD 6 L40 1 D UNV SU-WA 8 STD FC W	LED	120	55
SD1		H.E. WILLIAMS	LSQ60 L40C/840 DIM 120	LED	120	40
SR1		VISA	CM1900 L40K 120V 90CRI MWAC NGT	LED	120	126
SR2		KENALL	CSMRI44 G10 26L65K 24VDC AMF	LED	120	26
SR3		KENALL	MEIC22 G 38I/25L 43K9 DCC 120 FA AMF	LED	120	38
SR4		KENALL	M4SEDIC 22 75I/50L 43K9 DCC 120 2F SYM	LED	120	50
SR5		USAI	11W B2 S 10 LSTD6 9040 C2 27KS C35 NC2 120V DIM	LED	120	40
SW1		USAI	C4SZW CT 12CS1 6022KS GW 120V D19	LED	120	12

COM*check* Software Version 4.0.8.1

Interior Lighting Compliance Certificate

Section 1: Project Information

Energy Code: **2009 IECC**
Project Title: Murex
Project Type: New Construction

Construction Site: Owner/Agent: Designer/Contractor:

Section 2: Interior Lighting and Power Calculation

A Area Category	B Floor Area (ft2)	C Allowed Watts / ft2	D Allowed Watts (B x C)
Hosptial (Hospital)	460000	1.2	552000
		Total Allowed Watts =	552000

Section 3: Interior Lighting Fixture Schedule

A Fixture ID : Description / Lamp / Wattage Per Lamp / Ballast	B Lamps/ Fixture	C # of Fixtures	D Fixture Watt.	E (C X D)
Hosptial (Hospital 460000 sq.ft.)				
LED 1: SR1: SR1: Other:	1	235	126	29610
LED 2: SW1: SW1: Other:	1	705	12	8460
LED 3: RS1: RS1: Other:	1	315	29	9135
LED 4: RF1: RF1: Other:	1	235	25	5875
LED 5: CD1: CD1: Other:	1	570	12	6840
LED 6: RW1: RW1: Other:	1	300	55	16500
LED 7: LC1: LC1: Other:	1	8	71	568
LED 8: SR2: SR2: Other:	1	72	26	1872
LED 9: SD1: SD1: Other:	1	152	40	6080
LED 10: LC2: LC2: Other:	1	8	60	480
LED 11: SR3: SR3: Other:	1	200	38	7600
LED 12: SR4: SR4: Other:	1	96	50	4800
LED 13: BOOM: BOOM: Other:	1	24	1500	36000
LED 14: SR5: SR5: Other:	1	50	40	2000
LED 15: CD2: CD2: Other:	1	750	42	31500
LED 16: LP1: LP1: Other:	1	60	23	1380
			Total Proposed Watts =	168700

Section 4: Requirements Checklist

Interior Lighting PASSES: Design 69% better than code.

Lighting Wattage:

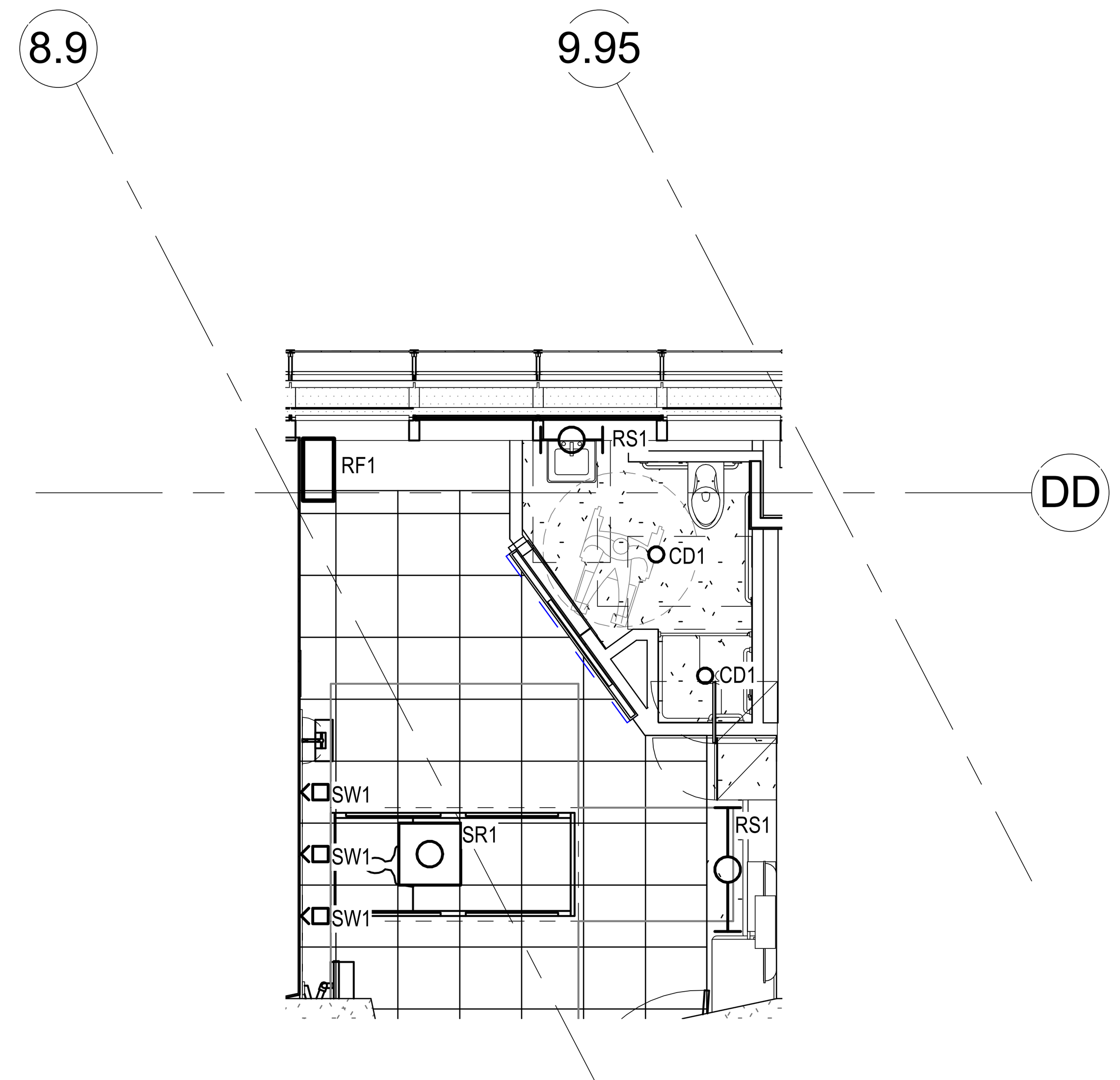
❑ 1. Total proposed watts must be less than or equal to total allowed watts.

Allowed Watts	Proposed Watts	Complies
552000	168700	YES

Controls, Switching, and Wiring:

❑ 2. Daylight zones under skylights more than 15 feet from the perimeter have lighting controls separate from daylight zones adjacent to vertical fenestration.

Project Title: Murex
Data filename: Untitled.cck
Report date: 02/18/18
Page 1 of 2



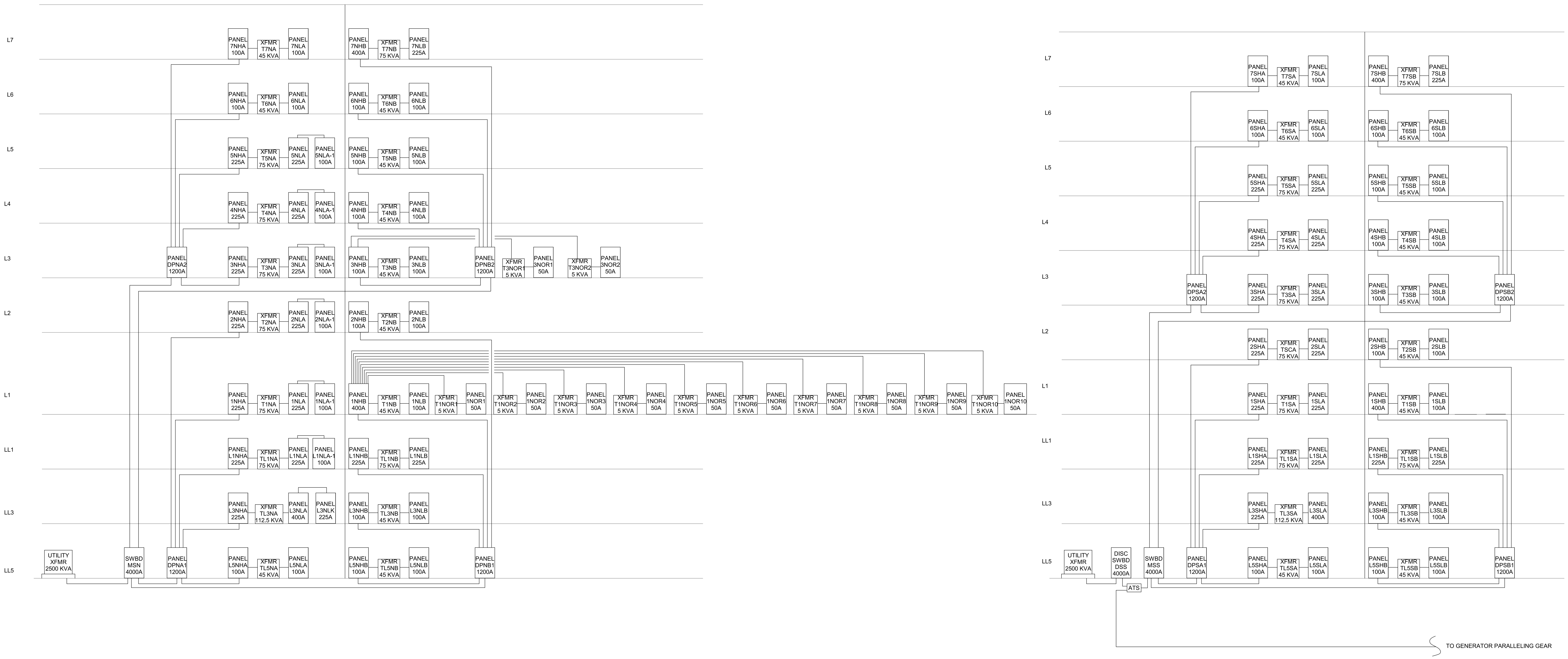
LIGHTING TYPICAL PATIENT ROOM

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL
& MEDICAL CENTER
OF OMAHA

TITLE
LIGHTING DOCUMENTATION

E-301



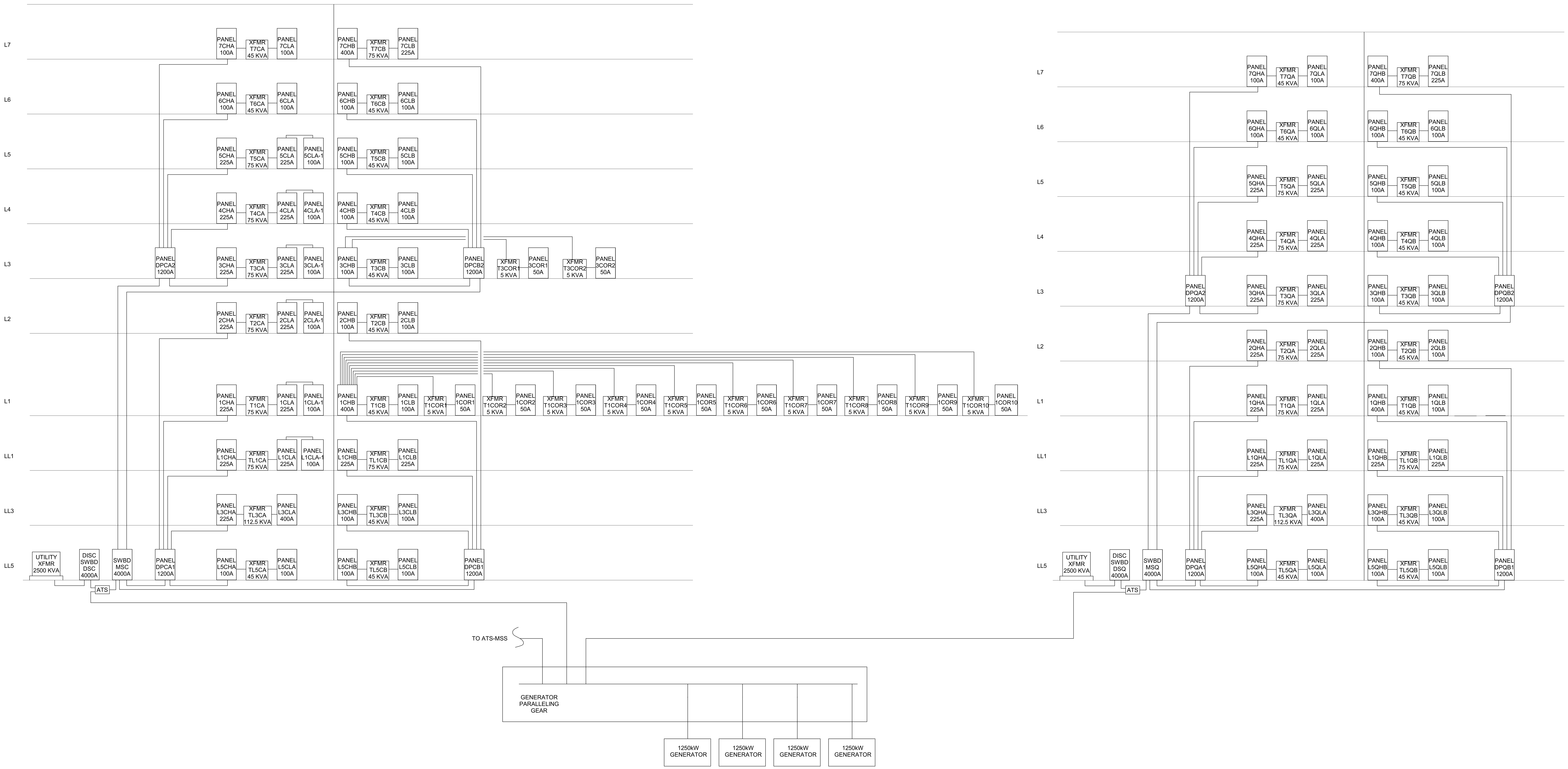
RISER DIAGRAM PART 1

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
RISER DIAGRAM

E-501



RISER DIAGRAM PART 2

MUREX
EST 2017-18

PROJECT
CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE
RISER DIAGRAM

E-502

5.1.0 Executive Summary

The Children's Hospital and Medical Center consists of a 10-story structure with unique design and system integration that the Murex design team has incorporated into the hospital. These designs require substantial coordination and planning. The Murex construction team has worked with the design team throughout an extensive pre-construction process to ensure all integrated design is properly built to given specifications. The construction phase will also incorporate unique processes to construct in a manner that exceeds the expectations of the owner by carefully coordinating the schedule, estimate, and safe delivery of the project.

SAFETY

EMR 0.8

Murex is able to achieve an Experience Modification Rating (EMR) of 0.8 which is below the industry average. Our team's dedication to safety on site and to personnel safety requirements has helped achieve such a high safety standard.

SCHEDULE

34 MO

Through the use of an Integrated Project Delivery method for design and construction as well as highly coordinated scheduling, the Children's Hospital and Medical Center project duration has been determined to be 34 months with a substantial completion date of March 4th, 2021.

COST OF CONSTRUCTION

$252 Million

With Aleternative

The Grand Total with the Add Alternates for the Children's Hospital and Medical Center in Omaha, Nebraska came out to be Two-Hundred Fifty-Two Million, Seventy-Two Thousand, Two Hundred Forty-Eight Dollars ($252,072,248).

5. Construction narrative

5.1.0 EXECUTIVE SUMMARY
5.2.0 Introduction
- 5.2.1 Project Overview
- 5.2.2 Project Goals
- 5.2.3 Integrated Project Delivery Method (IPD)

5.3.0 Planing
- 5.3.1 Site Visit
- 5.3.2 Site Logistics
- 5.3.3 Tower Crane Selection
- 5.3.4 Pre-Fabrication & BIM Modeling

5.4.0 Safety
- 5.4.1 Personal Protective Equipment
- 5.4.2 Safety Meetings and Safety Walks
- 5.4.4 Helicopter Protocol
- 5.4.5 Natural Disaster Response

5.5.0 Site Work
- 5.5.1 Excavation
- 5.5.2 Secant/Tangent Pile Shoring Method
- 5.5.3 Dewatering

5.6.0 Integrated Design and Construction
- 5.6.1 Drilled Piers/Energy Piles
- 5.6.2 Voided Slab System
- 5.6.3 Electrical(Smart Technology)

5.7.0 Construction Schedule
- 5.7.1 Scheduling Process
- 5.7.2 Schedule Summary
- 5.7.3 Milestones and Project Duration

5.8.0 Construction Estimate
- 5.8.1 Estimate Process
- 5.8.2 Grand Total
- 5.8.3 Integrated Design Alternates
- 5.8.4 Estimate Summary

5.9.0 Conclusion

5.2.0 INTRODUCTION

5.2.1 Project Overview

The Murex construction team, in careful collaboration with the design team, is excited to construct this 10-story Children's Hospital and Medical Center in a manner that exceeds the expectations of the owner by carefully coordinating the schedule, estimate, and overall delivery of the project. Ultimately, our goal is to provide the best end result, given the project parameters, that supports and enriches the future use of the building.

The Murex team will provide its services with the interests of the owner as our primary concern. We have undertaken many steps to ensure the schedule, estimate, and overall delivery of the finished product to the owner will be of the highest quality and a collaborative design experience. This document will identify the primary goals that we have achieved and the operational decisions and procedures necessary to achieve them.

5.2.2 Project Goals

Ensure safety of workers during construction Application of proven and innovative construction methods Minimize impact on existing hospital and surroundings Minimize vibration during construction Minimize traffic delays Schedule large deliveries at night to reduce traffic delays Coordination with crane and helicopter landings Allow space for emergency vehicles if roads are shut down Stay under budget

5.2.3 - Integrated Project Delivery Method

Integrated Project Delivery (IPD) is a project delivery approach that integrates the owner, designer, and contractor to allow for extensive collaboration between the parties. By using this structure, we will be able to harness the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. The IPD method has also allowed Murex to set more aggressive goals for sustainability.

The Murex construction team was able to sit in on numerous design meetings to give the designers our thoughts and to answer questions relating to constructability. Participation during the design phase provided us the opportunity for strong pre-construction planning, a greater understanding of the design and resolving any design-related issues before the construction phase. To increase the likelihood of achieving our project goals, the Murex team will visualize construction sequencing prior to construction start to control cost and manage the budget. Overall, the unique bond developed among all major project stakeholders has truly created a trusting relationship.

5.3.0 PLANNING

5.3.1 – Children's Hospital and Medical Center Site Visit

The Murex construction team visited the Children's Hospital and Medical Center project site. This site visit was helpful in determining the site logistics plan as well as understanding and visualizing the project as a whole. Some notable areas of the site were the transformer locations, entrance locations, hospital delivery locations, and potential material staging areas.

The figures above show elevated views of the site. Some items within the pictures to note are the transformers and site location relative to West Dodge Road.

The hospital deliveries were one of the most important takeaways from the site visit. The deliveries must be accommodated by construction operations in order to allow normal operations of the hospital. When visiting the site, it was noticed by the Murex team that there was a completely clear path as well as proper signage to notify delivery drivers of drop-off areas. Knowing where the delivery areas are located was also very helpful in deciding the locations of staging areas, job trailers, and material storage.

5.3.2 – Site Logistics

With the given site constraints, the construction team is cramped for space. Due to the limited space, the sidewalk to the north will be demoed and security fencing will be installed along the roadway to create as much room as possible for equipment maneuvering. The fencing will continue around the east and south sides of the site and terminate near the Emergency entrance to the existing hospital. The middle of the existing parking lot to the east will contain storage containers, office trailers and a laydown yard for materials such as reinforcing steel and recycled plastic voids. Two construction entrances are located on the south side of the site and construction parking will be located to the north of the site; across the road.

5.3.3 – Tower Crane Selection

For the tower crane, a Linden Comansa 21LC660-48t was selected based on the amount of reach needed for this site. This is a 48 Ton crane and has a maximum reach of 275 feet. The crane shall be located on the north side of the site where it can reach every corner of the building, as well as the laydown yard to be able to make picks as needed. The tower itself will be 210 feet which will allow proper clearance of both the existing and future buildings. According to the tower cranes specifications, the base will be 24 feet by 24 feet; which will be able to comfortably sit between the road and structure. During operation, proper swinging techniques will be critical to ensure no contact with the existing hospital shall happen. Being in constant communication with the hospital for helicopter landings will also be a very important aspect during hours of operation.

5.3.4 - Pre-Fabrication and BIM Modeling

The Murex design team is able to communicate their designs through BIM Modeling which the construction team can utilize in the building process. Models of structural, electrical, and mechanical systems will be used to prefabricate materials prior to installation. Pre-fabricating these materials will decrease installation time significantly by limiting site disruptions. This is beneficial for site logistics due to the lack of space for storage on the site. Another benefit of prefabrication is increased quality. This increased quality is a result of the controlled, consistent environment in which these components are fabricated.

5.4.0 - SAFETY

5.4.1 - Personal Protective Equipment

Safety is of the utmost importance in the construction process of any building. This is a major concern for all contractors and will be a high priority for Murex during the construction process. It is majorly important that everyone involved in the construction of the building understand the safety goals of the contractor. If everyone is made aware of the objectives that the contractor is trying to achieve as far as safety, the contractor will be far more effective in keeping everyone, including the public, as safe as possible.

The simplest means of safety begin with worker safety and worker equipment. This includes the requirement of the proper personal protective equipment as required by the Occupational Safety and Health Administration (OSHA). This personal protective equipment includes hard hats, protective eyewear, safety gloves, high visibility vests, and work boots adequate for construction work.

5.4.2 - Safety Meetings and Safety Walks

Along with the traditional means of safety required by OSHA, the Murex construction team plans to utilize other techniques to facilitate job site safety. The construction team will have weekly safety meetings with all crews on site. The team will also have daily safety walks where one of the Murex managers will walk the site and inspect it for any safety violations. All violations will be documented and the subs in violation will be notified. By making this a daily task, the Murex construction team can assure a clean and safe job site. All subcontractors will be required to complete task hazard analysis every time a new task has started.

5.4.3 - Helicopter Protocol

Another safety concern associated with this hospital project is the potential danger associated with the helicopter takeoffs and landings. Typically this would not be a major issue, but in this case, the helicopter pad is in the swinging radius of the tower crane. To avoid any issues or possible collisions, the crane operator will have a hard-wired microphone in the cab of the crane; this microphone will be connected to the existing hospital and the operator will be alerted of any helicopter activity. Hardwiring is necessary in the case of radio frequencies not matching up with walkie-talkies.

In the case of a helicopter landing or takeoff on the existing hospital, the operator must follow protocol as follows: 10 minutes before any takeoff or landing, the operator is to lower any suspended loads, detach from such load, rotate the crane to be parallel with West Dodge Road and set the crane's brake. The operator will remain out of operation until given the go-ahead by the Superintendent. Dependent upon the phase of construction, other precautions must be taken to ensure everyone on site and any bystanders are safe during helicopter activity. This includes properly securing any loose material or debris that could be affected by the helicopter's wind. The main goal is to keep everyone safe at all times.

5.4.4 - Natural Disaster Response

In the case of a natural disaster, all subcontractors on site will be equipped with a written plan to keep workers safe. Evacuation and take-cover plans will also be lined out in the Murex office trailer. These plans will be updated throughout the phases of construction to ensure the safety of all personnel on site.

5.5.0 - SITE WORK

5.5.1 Excavation

Exportation of excess soil for the Lower Level 5 and foundation excavation will be a major component of the construction process. Due to the adjacent road having heavy traffic flow, it was suggested to work our excavation crews at night. But most patient rooms are on the north side of the hospital and this would contradict our goal of not disrupting the current hospital and its occupants. The decision was made to operate between the hours of 9:00 AM and 5:00 PM. This time frame will miss the morning and evening rush hours. Lane closures may be necessary during this time as well, but due to the road being three lanes wide, we do not foresee any traffic issues during these temporary closures.

5.5.2 - Secant/Tangent Pile Shoring Method

Due to the existing structure and roadway adjacent to the site, extensive shoring methods will be used to ensure the existing hospital and roadway remain undisturbed. It is always a concern for movement and vibration working next to a hospital. Looking for the most cost-effective and safest way to shore such a large structure and the soil beneath; the shoring method selected for the site is to be Secant or Tangent Piles with Tiebacks. With this method being so effective in the past and able to remain in the soil without removal seems to be the most efficient support method of the existing structure and roadway. The piles will later be used as the forming system for the basement walls by placing forms on the inside to yield a properly finished basement wall.

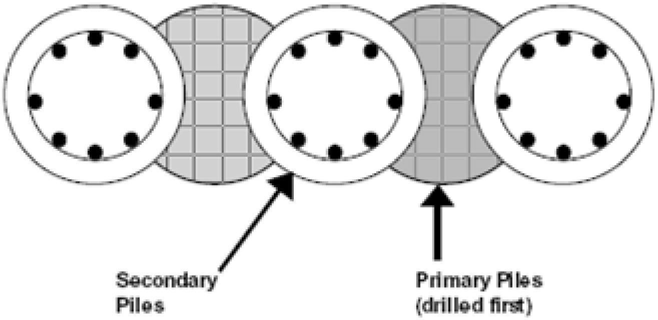


Figure above indicates the layout and sequencing of the Secant or Tangent Piles. The primary piles will be drilled and placed first with lightweight concrete. No reinforcing is needed for the primary piles, but the secondary piles consisting of high-strength concrete will be drilled and set between the primary piles. This overlapping method with the piles will strengthen the wall and ensure no groundwater seepage.

For this particular situation, the existing structure is massive and it places a large load on the soil beneath; to ensure the stability of the adjacent structure during excavation and throughout below grade construction, post-tensioned tiebacks will be placed through the wall where they can anchor to the soil behind. Figure above shows a similar shoring situation with the piles having the anchoring system in place. These tiebacks will be carefully planned and placed to miss any structural elements behind the wall that may be associated with the structure above.

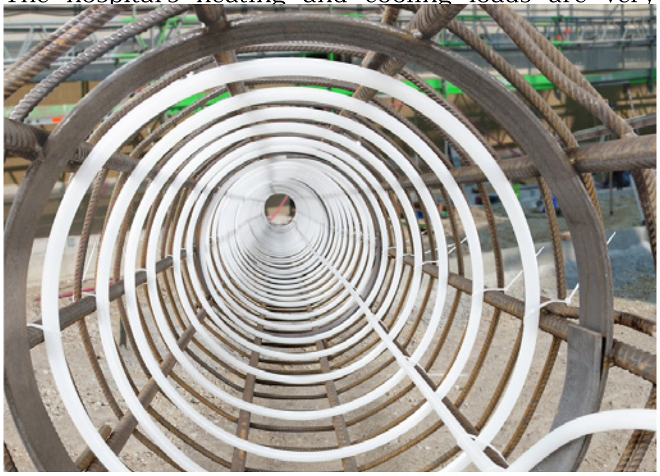
5.5.3 - Dewatering

After analyzing the soil boring tests from the site, it is known that groundwater will be a problem due to Lower Level 5 (basement) sitting 30 feet below grade. The tangent piles are capable of acting as a water barrier, so excavation will be able to remove the soil without the installation of significant dewatering systems. But for precautions, pumps will be on hand in case of water intrusion.

5.6.0 – INTEGRATED DESIGN AND CONSTRUCTION

5.6.1 – Drilled Piers/Energy Piles

The hospital's heating and cooling loads are very



substantial, but one innovative and sustainable way those loads can be supported is with the use of drilled piers incorporating geothermal tubing placed within them. Geothermal systems use piped water to collect heat from the Earth's subsoil; the collecting of this "energy" will go towards the buildings heating and cooling system. The hospital's foundation consists of 72 drilled piers 65 of which will be energy piers. These piers are 36 inches in diameter and will be placed at a depth of 89 feet below the slab-on-grade.

The geothermal piping that will be included in the piers will consist of tubing attached to the reinforcing of the concrete piers. This piping will be continuous throughout the pier and will allow for the transfer of heat from the earth to the water that is pumped through the piping. This integration of the foundation system and the and cooling of the building is one way the design team will be able to effectively cool the building while maintaining smaller cooling towers, and without disturbing the structural integrity of the building.

These drilled piers will present the construction team with multiple challenges. These challenges will be met with the proper scheduling, coordination, and teamwork necessary to place each drilled pier within the specific time frame allotted for the pier. This will be done by preparing the drilled piers' reinforcement and geothermal piping in advance so that each pier is ready to have reinforcing placed and be poured within the same day of the completion of drilling the pier. The reinforcing for each drilled pier will then be secured using an attachment that will hold the reinforcing and geothermal piping in the correct position until the concrete has had time to cure.

The geothermal piping that is placed within the drilled

pier will be fragile due to its material composition. Because of this, it will be important that the contractor as well as whoever is placing the concrete be aware of this fragility and work with the piping accordingly. It is also essential that the piping is protected after the piers have been placed so that none of these are damaged in any way. This protection may be as simple as connecting the piping together and placing bright colored flags on the pipes to help workers avoid stepping on them. It may also require protection using various materials such as foam or cloth wraps as damage to these would greatly affect the flow of the project as well as the mechanical system as a whole.

5.6.2 – Voided Slab System

Voided slabs present an opportunity for the Murex construction team to show operating and management skills necessary for the coordination of such materials. These slabs will be used on each floor excluding the basement slab and will reduce the total amount of concrete used by a considerable amount. This reduction of concrete creates less need for pumping concrete to upper areas of the building which also means a smaller amount of manpower needed for the concrete portion of this project. These slabs, while beneficial in the concrete scope, present challenges in other areas of the job such as site logistics, scheduling, and crane operation. Site logistics for this project are the main concern as

there is a limited amount of space within the site. This is important to keep in mind because materials that will be used for the voided slab system will take up a large amount of space that will have to be collaboratively organized with all subcontractors working on site. It is necessary that everyone on the site understands where materials need to be placed to keep a well-maintained and functional work-site. The parking lot that is located to the south-east of the job site will be used as the main area for storing materials. Scheduling of lead times for material storage will need to be coordinated with the general contractor and other subcontractors.

The site logistics associated with the voided slab ties into the schedule of the project as well. With this in mind, these supplies have to be accounted for in the site logistics portion of the construction plan so as to free as much space as possible, as soon as possible for other materials being shipped to the site. The voided slabs must be moved to the site and utilized quickly in order to keep everything else on the schedule.

5.6.3 - Electrical (Smart Technology)

For the work requiring electrical connection prior to the interior finish work of the building, it is necessary to note the locations of the transformers within the site. In the case of the Children's Hospital and Medical Center project, the existing transformers are located northeast of the existing hospital building meaning that site projects requiring power will have to be coordinated with this location in mind. Also, temporary power for on the site operations will need to be coordinated with the existing hospital. New transformers will be installed early in the construction process to allow for temporary power connections as well as final power supply for the new structure.

The electrical work within the building requires special attention to detail to be sure that each room is built to the highest level of quality possible. With this in mind, some of the more complicated rooms within the building will be the operating rooms, the intensive care units (ICU's), and the critical care units (CCU's).

This emphasis on quality of the operating rooms, ICU's, and CCU's is especially important in the later phases of construction. The finishes portion of the project will play a major role in the completion of these parts of the hospital to the standards of the owner's desire.

Another important consideration in the electrical scope of work is the integration of the smart building technology into the rest of the electrical services of the building. It will be crucial for Murex when installing the smart technology to have an understanding of how it operates with all of the major and minor electrical work within the building. It is also necessary that the contractor have a general understanding of the electrical loads that will be necessary to supply the smart building technology.

The Murex construction team will hire a consultant to work alongside a subcontractor to develop the communication systems within the building. The consultant's and subcontractor's prior knowledge of the electrical systems will be useful in coordination and sequencing of the smart technology.

5.7.0 - CONSTRUCTION SCHEDULE

5.7.1 - Scheduling Process

The success of a construction project is determined by many things including completion within a certain time constraint. A construction schedule is the main driver of the construction process. The schedule determines the time logistics for the project as a whole and is critical for a successful project. When determining the schedule for a project, many factors must be considered. This includes not only the actual duration of the work to be performed, but also the lead times for certain materials and equipment, and pre-construction services.

Consideration of the major components of the project will be effective in creating the initial schedule for the Children's Hospital and Medical Center. After these areas are considered, the sub-contracted and specialty scopes of work will be accounted for by utilizing pull planning, just in time deliveries, and a last planner system. These methods of scheduling will be helpful in minimizing the duration of the project as well as reducing costs by way of timely deliveries.

A way for the construction team to understand if they are staying on schedule is to utilize milestones. Milestones are not events within the schedule but represent the completion of certain pieces of the project. Some milestones that are significant in the completion of the project include finishing of preconstruction services, completion of the exterior envelope, and substantial completion of the project. It will be helpful for managers of the project to make these milestones part of their daily, weekly, and monthly goals. This will keep everyone on the same time-frame from the beginning of construction until the completion date.

5.7.2 – Schedule Summary

The critical path of the Children's Hospital and Medical Center consists of the events necessary to complete the project within the designated time constraint. This path relies on the major milestones of the project outlined below. An example of the aforementioned sections is included in the figure below.

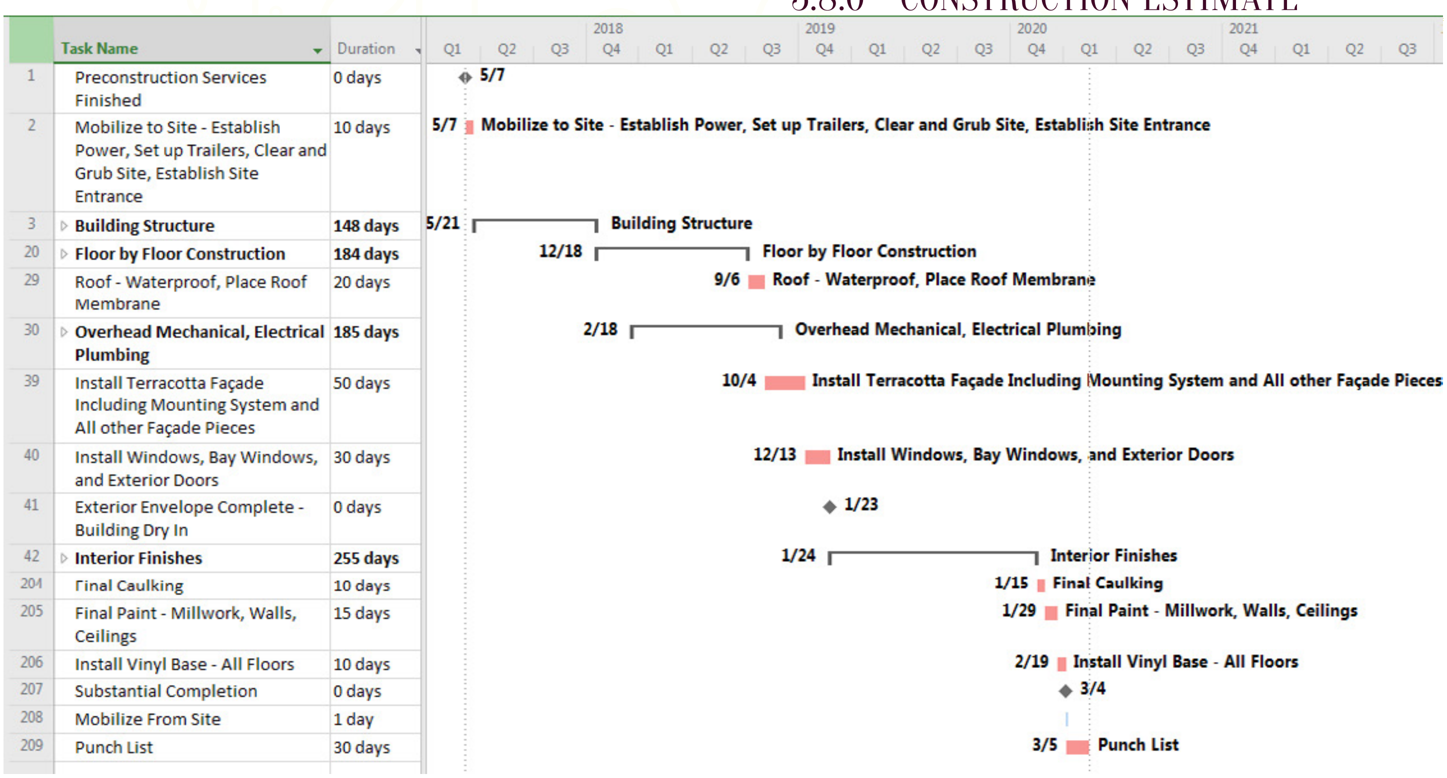
5.7.3 – Milestones and Project Duration

Some important events within the schedule to note are the start date, various milestones, and the completion date. The date the construction project starts is May 7th, 2018. This date must be preceded by a number of things including the completion of the preconstruction services, notice to proceed, access to the site, the acquisition of the proper building permits, receipt of a signed contract, and receipt of owner financing.

Once the project has begun, the progress of the project will be determined by the completion of tasks within milestones. Some of these milestones include completion of the building structure, completion of the exterior envelope of the building, and substantial completion of the project. Each of these milestones plays an important role in the delivery of the project. If the building structure is not complete, the tasks that depend on this completion such as drying in the building will be much more difficult to achieve.

Substantial completion of the project is scheduled to be completed March 4th, 2021. This will be followed by a punch list that will be determined at the end of the project and will be completed during the beginning of operation of the hospital. The construction team will coordinate with the hospital during this phase of the project to avoid construction workers hindering the hospital's function.

The duration of the total project was concluded at 34 months. This is from the beginning of mobilization to the site to the substantial completion of the project. This schedule was developed using RS Means 2017 data for construction of similar type buildings and building materials. An estimate of the timeframes for each portion of the project was then made and inserted into Microsoft Project in order to create a list of items as well as a Gantt chart to show the order of items and their preceding and succeeding tasks. This schedule will be helpful throughout the entire duration of the project for all people within every scope of construction.



	Task Name	Duration
1	Preconstruction Services Finished	0 days
2	Mobilize to Site - Establish Power, Set up Trailers, Clear and Grub Site, Establish Site Entrance	10 days
3	Building Structure	148 days
20	Floor by Floor Construction	184 days
29	Roof - Waterproof, Place Roof Membrane	20 days
30	Overhead Mechanical, Electrical Plumbing	185 days
39	Install Terracotta Façade Including Mounting System and All other Façade Pieces	50 days
40	Install Windows, Bay Windows, and Exterior Doors	30 days
41	Exterior Envelope Complete - Building Dry In	0 days
42	Interior Finishes	255 days
204	Final Caulking	10 days
205	Final Paint - Millwork, Walls, Ceilings	15 days
206	Install Vinyl Base - All Floors	10 days
207	Substantial Completion	0 days
208	Mobilize From Site	1 day
209	Punch List	30 days

5.8.0 – CONSTRUCTION ESTIMATE

5.8.1 – Estimate Process

The estimate take-off for the newly proposed Children's Hospital in Omaha, Nebraska is comprised of historic averages of other similar 10-story hospital projects and detailed research for unique items. Bluebeam Revu 2017 Estimating Software and Microsoft Excel Spreadsheets were utilized in creating this estimate.

Using the RS Means books, the team was able to price out the hospital based on current trends in today's healthcare construction industry. Average costs for materials as well as subcontractor fees have been included in the estimate which also contributes to the total estimate. These averages are calculating the total for specific subcontractor phases of the construction process for each floor of the project. Then fees for Overhead, Profit, General Requirements, and Architect Fees are broken out to be accounted for per floor.

5.8.2 – Grand Total

The estimate has a focus on floor levels two through five. This primary estimate covers the Neonatal Intensive Care Unit (NICU), Fetal Care Center, Cardiac Care Unit (CCU), and the Pediatric Intensive Care Unit (PICU). All other floors follow the same estimate format.

The Grand Total for the Children's Hospital and Medical Center came out to be Two Hundred and Seven Million, Forty-Eight Thousand, Four Hundred and Forty-Eight Dollars.

($207,048,448)

5.8.3 – Integrated Design Alternates

Alternates have been broken out based on the integrated design done by the Murex Design Team. The specific systems can be incorporated into the new Children's Hospital with the exception of the alternate. These alternates have been priced as follows:

Alternate #1	Voided Slab System	($4,677,660)
Alternate #2	Energy Piles	($751,530)
Alternate #3	Terrart Wall System	($33,321,600)
Alternate #4	Shelters	($2,350,000)
Alternate #5	Smart Control System	($3,923,010)

The Grand Total with the Add Alternates for the Children's Hospital and Medical Center in Omaha, Nebraska came out to be Two Hundred Fifty-Two Million, Seventy-Two Thousand, Two Hundred Forty-Eight Dollars

($252,072,248).

5.8.4 – Estimate Summary

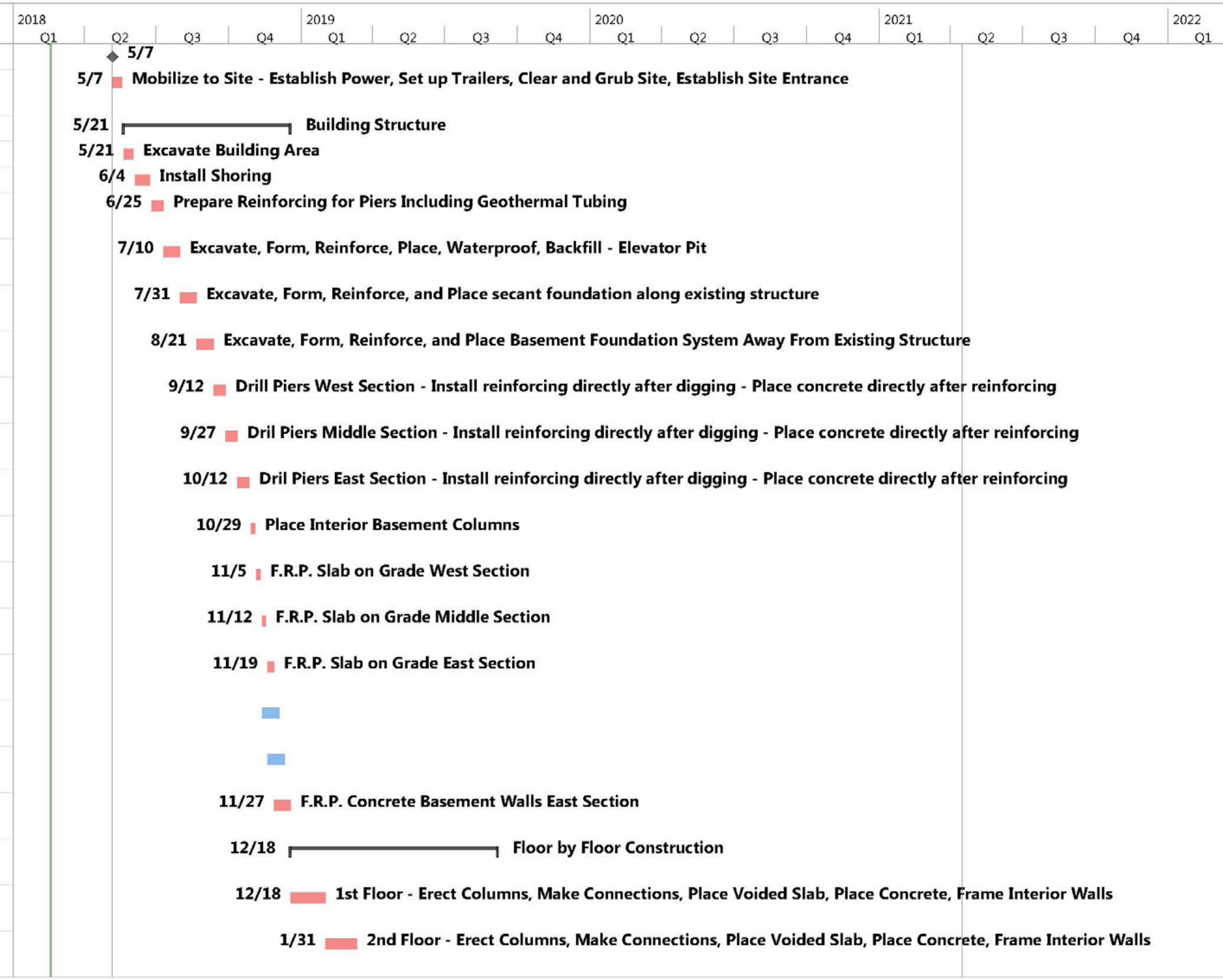
Estimate Summary			
Lower Level 5	Total =	$	23,700,487.31
Lower Level 3	Total =	$	25,480,598.99
Lower Level 1	Total =	$	22,942,289.52
Level 1	Total =	$	21,539,979.52
Level 2	Total =	$	18,431,710.77
Level 3	Total =	$	18,431,710.77
Level 4	Total =	$	18,431,710.77
Level 5	Total =	$	18,431,627.67
Level 6	Total =	$	18,431,009.09
Level 7	Total =	$	18,793,295.98
Miscelaneous	Total =	$	2,434,027.78
Alternate #1: Voided Slab System	Total =	$	4,677,660.00
Alternate #2: Energy Piles	Total =	$	751,530.00
Alternate #3: Terrat Wall System	Total =	$	33,321,600.00
Alternate #4: Shelters	Total =	$	2,350,000.00
Alternate #5: Smart Building Control Systems	Total =	$	3,923,010.00
	Omaha Childrens Hospital Grand Total =	$	207,048,448.14
	Grand Total Including Add Alternates =	$	252,072,248.14

5.9.0 – CONCLUSION

The Children's Hospital and Medical Center project presented the construction team with many unique opportunities to test our knowledge of the pre-construction and building process needed to complete such project. The communication between the construction and design teams is crucial. It was necessary for each of the teams to understand the possibilities as well as the limitations of design and construction. An example of this is the geothermal piers. The piers are a great idea for providing the building with a source of heat. By communicating this with the design team, an understanding of the true time and resource commitments of the piers was reached. By understanding the potential for heat from the earth as well as the constructability of these piers, the team was able to come up with a reasonable approach to the geothermal piers.

Through collaboration, a final product that will be not only attractive but also functional and long-lasting will be achieved. The construction team in conjunction with the design team for the Children's Hospital project are determined to provide the owner with the most complete, and satisfactory project possible. With the proper planning of the project, coordination of tasks and materials, and collaboration of owner and constructor, the production of the building will greatly increase and thus better meet the expectations of the owner.

ID	Task Name	Duration
1	Preconstruction Services Finished	0 days
2	Mobilize to Site - Establish Power, Set up Trailers, Clear and Grub Site, Establish Site Entrance	10 days
3	**Building Structure**	**148 days**
4	Excavate Building Area	10 days
5	Install Shoring	15 days
6	Prepare Reinforcing for Piers Including Geothermal Tubing	10 days
7	Excavate, Form, Reinforce, Place, Waterproof, Backfill - Elevator Pit	15 days
8	Excavate, Form, Reinforce, and Place secant foundation along existing structure	15 days
9	Excavate, Form, Reinforce, and Place Basement Foundation System Away From Existing Structure	15 days
10	Drill Piers West Section - Install reinforcing directly after digging - Place concrete directly after reinforcing	11 days
11	Dril Piers Middle Section - Install reinforcing directly after digging - Place concrete directly after reinforcing	11 days
12	Dril Piers East Section - Install reinforcing directly after digging - Place concrete directly after reinforcing	11 days
13	Place Interior Basement Columns	5 days
14	F.R.P. Slab on Grade West Section	5 days
15	F.R.P. Slab on Grade Middle Section	5 days
16	F.R.P. Slab on Grade East Section	5 days
17	F.R.P. Concrete Basement Walls West Section	15 days
18	F.R.P. Concrete Basement Walls Middle Section	15 days
19	F.R.P. Concrete Basement Walls East Section	15 days
20	**Floor by Floor Construction**	**184 days**
21	1st Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	28 days
22	2nd Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	28 days



Project: Schedule FINAL.mpp
Date: Sun 2/18/18

Task	Inactive Task	Manual Summary Rollup	External Milestone	Manual Progress
Split	Inactive Milestone	Manual Summary	Deadline	
Milestone	Inactive Summary	Start-only	Critical	
Summary	Manual Task	Finish-only	Critical Split	
Project Summary	Duration-only	External Tasks	Progress	

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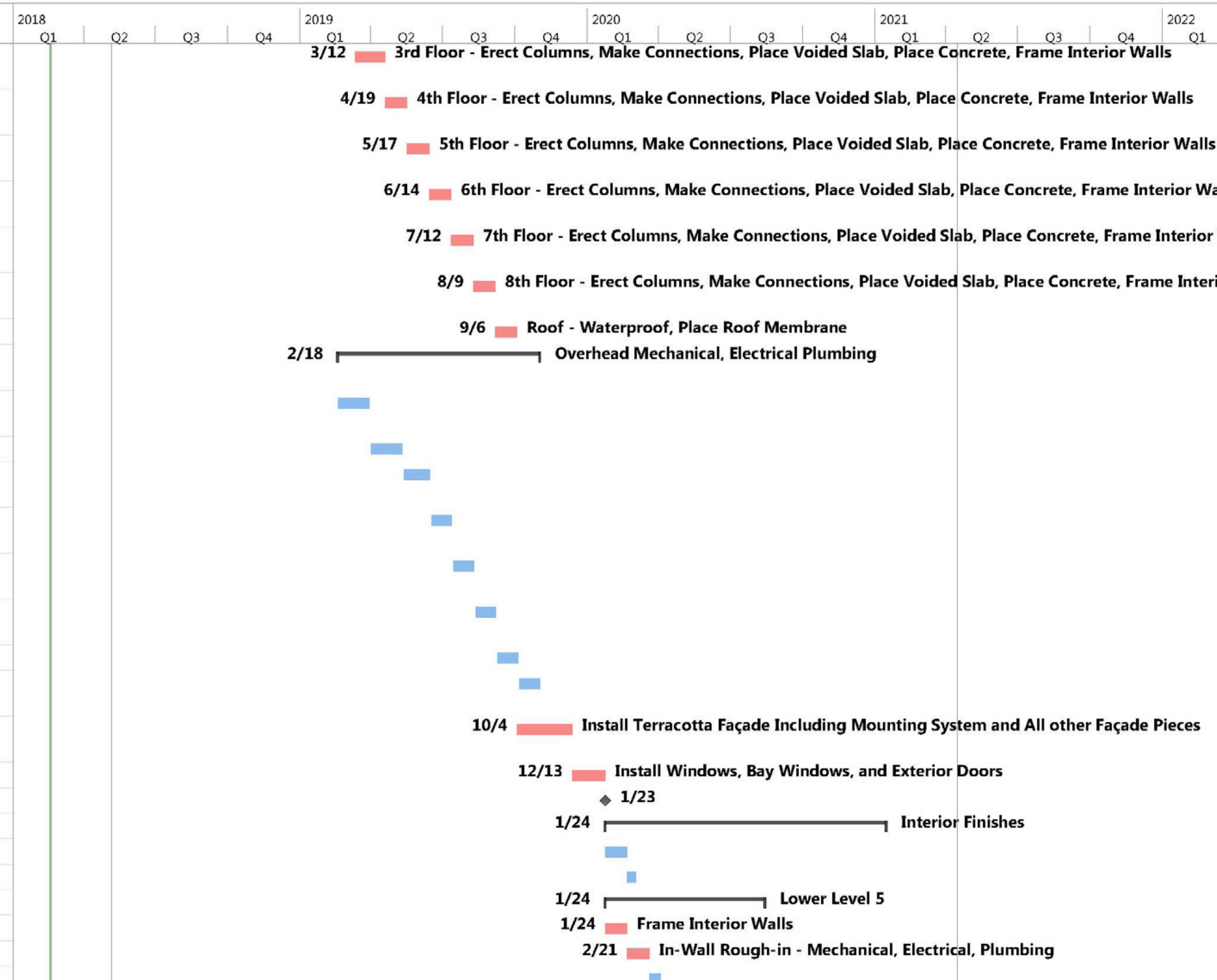
ID	Task Name	Duration
23	3rd Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	28 days
24	4th Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	20 days
25	5th Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	20 days
26	6th Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	20 days
27	7th Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	20 days
28	8th Floor - Erect Columns, Make Connections, Place Voided Slab, Place Concrete, Frame Interior Walls	20 days
29	Roof - Waterproof, Place Roof Membrane	20 days
30	**Overhead Mechanical, Electrical Plumbing**	**185 days**
31	Mechanical, Electrical, Plumbing Rough-in 1st Floor	30 days
32	Mechanical, Electrical, Plumbing Rough-in 2nd Floor	30 days
33	Mechanical, Electrical, Plumbing Rough-in 3rd Floor	25 days
34	Mechanical, Electrical, Plumbing Rough-in 4th Floor	20 days
35	Mechanical, Electrical, Plumbing Rough-in 5th Floor	20 days
36	Mechanical, Electrical, Plumbing Rough-in 6th Floor	20 days
37	Mechanical, Electrical, Plumbing Rough-in 7th Floor	20 days
38	Mechanical, Electrical, Plumbing Rough-in 8th Floor	20 days
39	Install Terracotta Façade Including Mounting System and All other Façade Pieces	50 days
40	Install Windows, Bay Windows, and Exterior Doors	30 days
41	Exterior Envelope Complete - Building Dry In	0 days
42	**Interior Finishes**	**255 days**
43	Install Elevators	20 days
44	Place HVAC Main Units In Basement Mechanical Room	7 days
45	**Lower Level 5**	**145 days**
46	Frame Interior Walls	20 days
47	In-Wall Rough-in - Mechanical, Electrical, Plumbing	20 days
48	Install Smart Building Technology	10 days



Project: Schedule FINAL.mpp
Date: Sun 2/18/18

Task	Inactive Task	Manual Summary Rollup	External Milestone	Manual Progress
Split	Inactive Milestone	Manual Summary	Deadline	
Milestone	Inactive Summary	Start-only	Critical	
Summary	Manual Task	Finish-only	Critical Split	
Project Summary	Duration-only	External Tasks	Progress	

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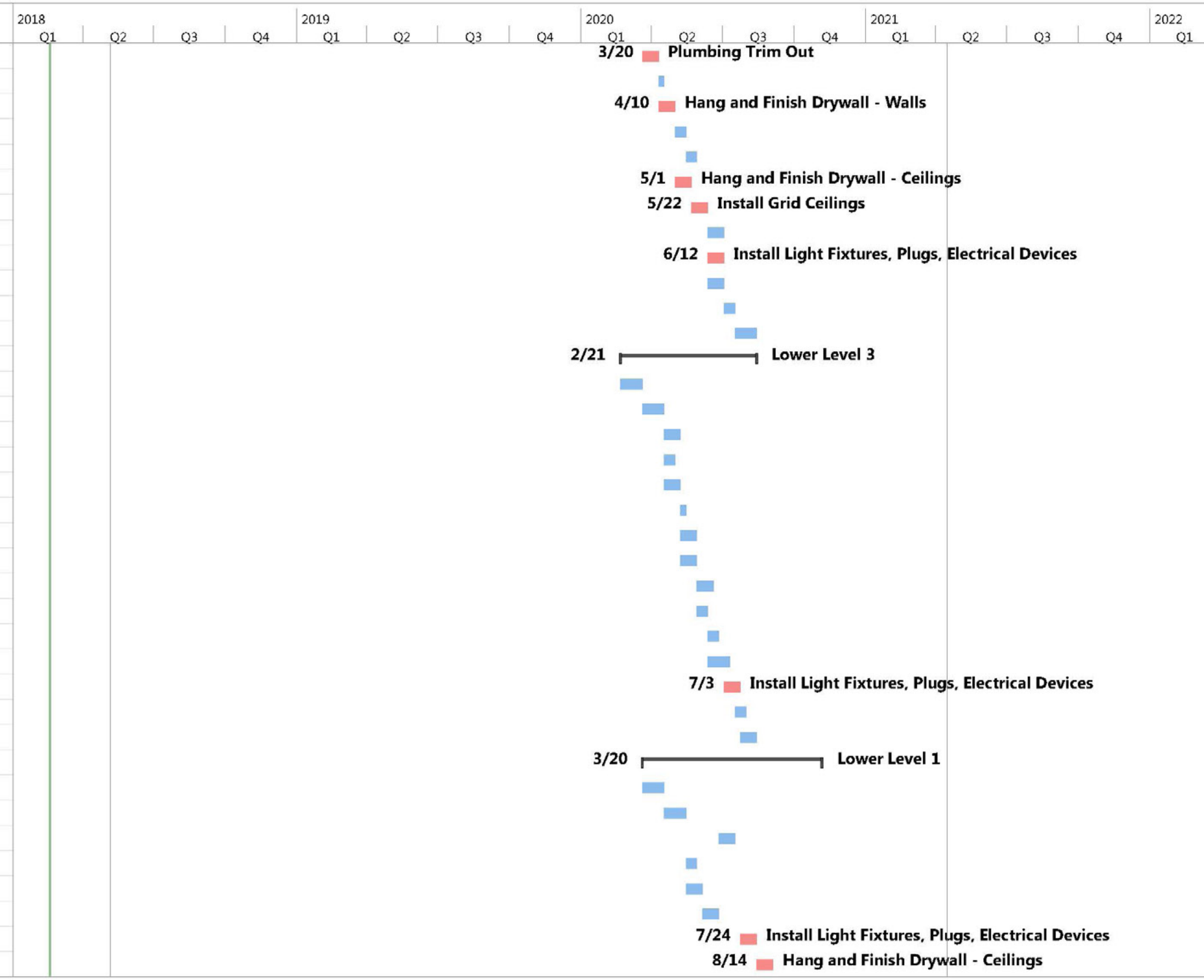
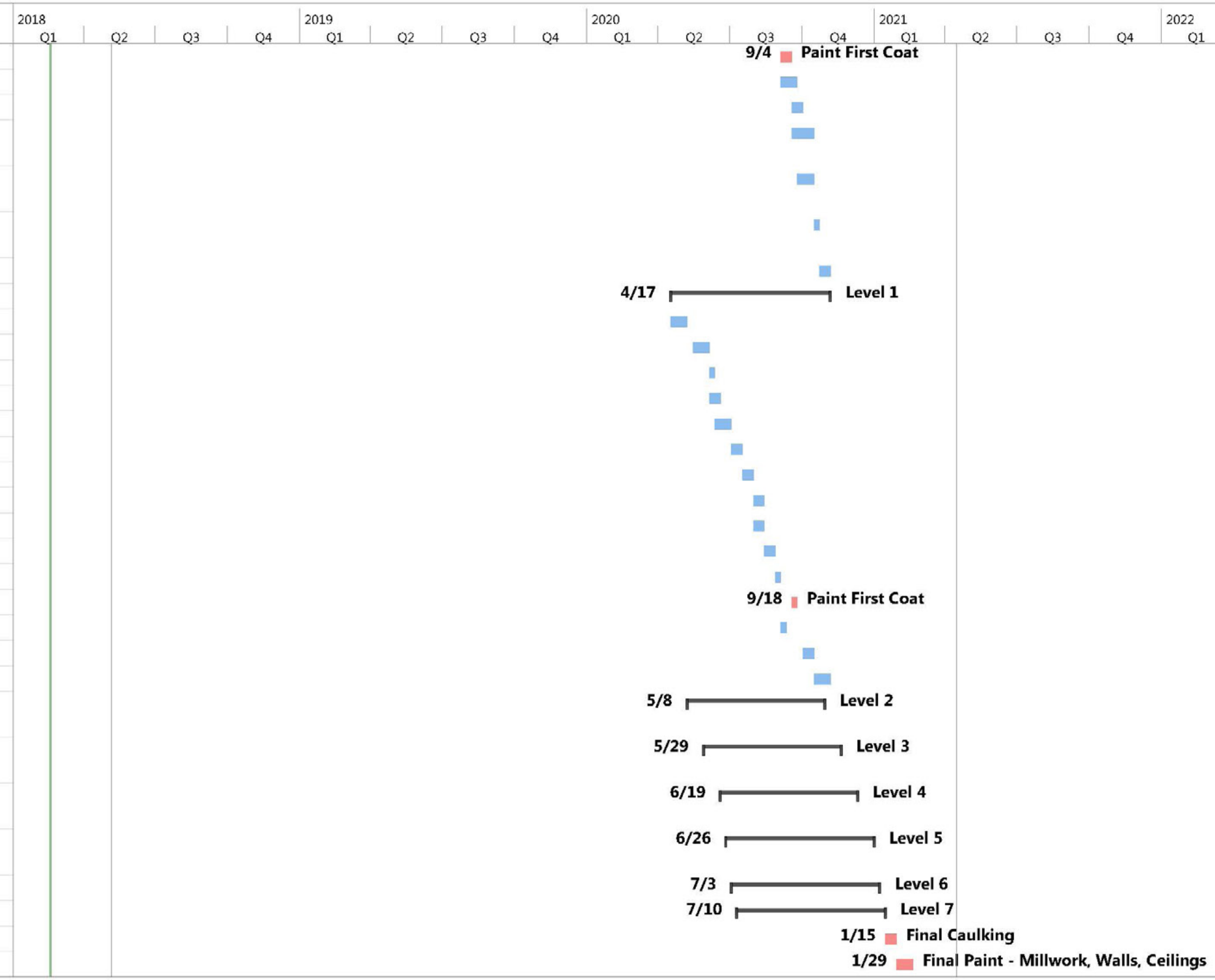
ID	Task Name	Duration
49	Plumbing Trim Out	15 days
50	Adjust Fire Sprinklers	5 days
51	Hang and Finish Drywall - Walls	15 days
52	Paint First Coat	10 days
53	Install Doors and Door Hardware	10 days
54	Hang and Finish Drywall - Ceilings	15 days
55	Install Grid Ceilings	15 days
56	HVAC Trim Out	15 days
57	Install Light Fixtures, Plugs, Electrical Devices	15 days
58	Misc. Trim Out	15 days
59	Install Ceiling Tiles	10 days
60	Install Flooring - Carpet, Tile, Laminate	20 days
61	**Lower Level 3**	**125 days**
62	Frame Interior Walls	20 days
63	In-Wall Rough-in - Mechanical, Electrical, Plumbing	20 days
64	Hang and Finish Drywall - Walls	15 days
65	Install Smart Building Technology	10 days
66	Plumbing Trim Out	15 days
67	Adjust Fire Sprinklers	5 days
68	Hang and Finish Drywall - Ceilings	15 days
69	Install Grid Ceilings	15 days
70	HVAC Trim Out	15 days
71	Paint First Coat	10 days
72	Install Doors and Door Hardware	10 days
73	Install Flooring - Carpet, Tile, Laminate	20 days
74	Install Light Fixtures, Plugs, Electrical Devices	15 days
75	Install Ceiling Tiles	10 days
76	Misc. Trim Out	15 days
77	**Lower Level 1**	**165 days**
78	Frame Interior Walls	20 days
79	In-Wall Rough-in - Mechanical, Electrical, Plumbing	20 days
80	Install Grid Ceilings	15 days
81	Install Smart Building Technology	10 days
82	Plumbing Trim Out	15 days
83	Hang and Finish Drywall - Walls	15 days
84	Install Light Fixtures, Plugs, Electrical Devices	15 days
85	Hang and Finish Drywall - Ceilings	15 days



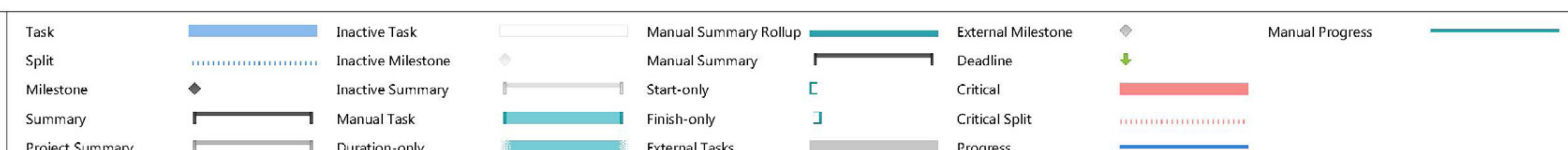
Project: Schedule FINAL.mpp
Date: Sun 2/18/18

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Critical | Critical Split | Progress | Manual Progress

ID	Task Name	Duration
86	Paint First Coat	10 days
87	HVAC Trim Out	15 days
88	Install Doors and Door Hardware	10 days
89	Install Flooring - Carpet, Tile, Laminate	20 days
90	Misc. Trim Out	15 days
91	Adjust Fire Sprinklers	5 days
92	Install Ceiling Tiles	10 days
93	**Level 1**	**145 days**
94	Frame Interior Walls	15 days
95	In-Wall Rough-in - Mechanical, Electrical, Plumbing	15 days
96	Install Smart Building Technology	5 days
97	Plumbing Trim Out	10 days
98	Hang and Finish Drywall - Ceilings	15 days
99	Hang and Finish Drywall - Walls	10 days
100	Install Grid Ceilings	10 days
101	HVAC Trim Out	10 days
102	Install Light Fixtures, Plugs, Electrical Devices	10 days
103	Misc. Trim Out	10 days
104	Adjust Fire Sprinklers	5 days
105	Paint First Coat	5 days
106	Install Ceiling Tiles	5 days
107	Install Doors and Door Hardware	10 days
108	Install Flooring - Carpet, Tile, Laminate	15 days
109	**Level 2**	**125 days**
125	**Level 3**	**125 days**
141	**Level 4**	**125 days**
157	**Level 5**	**135 days**
173	**Level 6**	**135 days**
189	**Level 7**	**135 days**
204	Final Caulking	10 days
205	Final Paint - Millwork, Walls, Ceilings	15 days



Project: Schedule FINAL.mpp
Date: Sun 2/18/18



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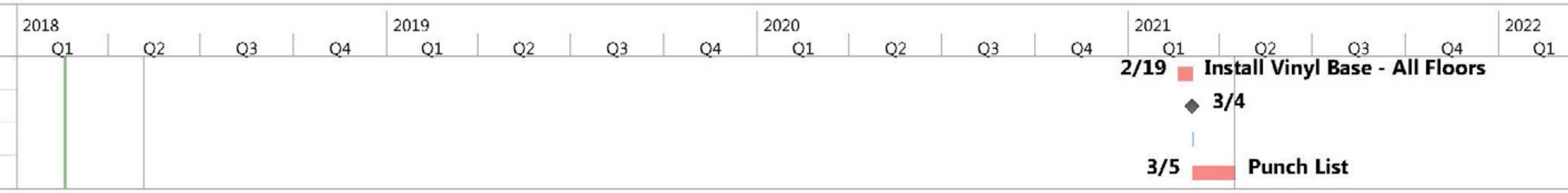
ID	Task Name	Duration
206	Install Vinyl Base - All Floors	10 days
207	Substantial Completion	0 days
208	Mobilize From Site	1 day
209	Punch List	30 days



Project: Schedule FINAL.mpp
Date: Sun 2/18/18

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Critical | Critical Split | Progress | Manual Progress

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Lower Level 5							
			COST PER UNIT		ADDITIONAL COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
Excavation	23,256	CY	$ 133.23	$ 3,098,337.67	$ 200.00	$ 4,651,111.11	$ 7,749,448.78
Slab on Grade	645	CY	$ 133.23	$ 85,978.87	$ 200.00	$ 129,068.33	$ 215,047.20
Flooring							
Sheet Vinyl Flooring	20406.75	SF	$ 9.00	$ 183,660.75			$ 183,660.75
Vinyl Composite Tile	31918.25	SF	$ 10.00	$ 319,182.50			$ 319,182.50
Shell							
Superstructure							
Floor Construction	52,325	SF	$ 12.42	$ 649,876.50	$ 14.90	$ 779,642.50	$ 1,429,519.00
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Interior							
Interior Doors	469	SF	$ 9.26	$ 4,345.72	$ 1,251.00	$ 218,925.00	$ 223,270.72
Ceiling	52325	SF	$ 5.89	$ 308,194.25	$ 3.38	$ 591.50	$ 308,785.75
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 5.89	$ 41,230.00	$ 93,730.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,445.00	$ 32,153.38
Plumbing							
Plumbing Fixtures	101.7759036	SF	$ 7.39	$ 752.12	$ 3,074.00	$ 312,859.13	$ 313,611.25
Domestic Water Distribution	52325	SF	$ 12.44	$ 650,923.00	$ 12.44	$ 650,923.00	$ 1,301,846.00
HVAC							
Distribution Equipment	52325	SF	$ 4.25	$ 222,381.25	$ 4.25	$ 222,381.25	$ 444,762.50
Cool Generating Systems	52325	SF	$ 3.10	$ 162,207.50	$ 3.10	$ 162,207.50	$ 324,415.00
Fire Protection							
Sprinklers	52,325	SF	$ 3.06	$ 160,114.50	$ 3.06	$ 160,114.50	$ 320,229.00
Electrical							
Electrical Service/Distribution	52,325	SF	$ 2.31	$ 120,870.75	$ 2.31	$ 120,870.75	$ 241,741.50
Lighting & Branch Wiring	52,325	SF	$ 40.00	$ 2,093,000.00	$ 20.94	$ 1,095,685.50	$ 3,188,685.50
Communications & Security	52,325	SF	$ 2.56	$ 133,952.00	$ 2.56	$ 133,952.00	$ 267,904.00
Specialty Electrical Systems	52,325	SF	$ 4.84	$ 253,253.00	$ 4.84	$ 253,253.00	$ 506,506.00
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 17,686,930.83
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 4,421,732.71
						ARCHITECT FEES 9% =	$ 1,591,823.77
						LOWER LEVEL 5 ESTIMATE TOTAL=	$ 23,700,487.31

Lower Level 3							
			COST PER UNIT		ADDITIONAL COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
Lower Level 3	52,325	SF					
Flooring							
Sheet Vinyl Flooring	20406.75	SF	$9	$ 183,660.75	$ 20.00	$ 408,135.00	$ 591,795.75
Vinyl Composite Tile	31918.25	SF	$10	$ 319,182.50	$ 20.00	$ 638,365.00	$ 957,547.50
Shell Superstructure							
Floor Construction	52325	SF	$ 12.42	$ 649,876.50	$ 14.90	$ 779,642.50	$ 1,429,519.00
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure							
Exterior Walls	9600	SF	$4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Exterior Doors	9600	SF	$0.83	$ 7,968.00	$ 5,971.00	$ 5,971.00	$ 13,939.00
Interior							
Interior Doors	469	SF	$9.26	$ 4,345.72	$ 1,251.00	$ 218,925.00	$ 223,270.72
Ceiling	52325	SF	$5.89	$ 308,194.25	$ 3.38	$ 591.50	$ 308,785.75
Interior Smart Finishes	52325	SF	$23.25	$ 1,216,556.25	$ 18.75	$ 981,093.75	$ 2,197,650.00
Interior Wall Finishes	7,000	LF	$7.50	$ 52,500.00	$ 5.89	$ 41,230.00	$ 93,730.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,445.00	$ 32,153.38
Plumbing							
Plumbing Fixtures	101.7759	SF	$7.39	$ 752.12	$ 3,074.00	$ 312,859.13	$ 313,611.25
Domestic Water Distribution	52325	SF	$12.44	$ 650,923.00	$ 12.44	$ 650,923.00	$ 1,301,846.00
HVAC							
Distribution Equipment	52325	SF	$4.25	$ 222,381.25	$ 4.25	$ 222,381.25	$ 444,762.50
Cool Generating Systems	52325	SF	$3.10	$ 162,207.50	$ 3.10	$ 162,207.50	$ 324,415.00
Fire Protection							
Sprinklers	52,325	SF	$3.06	$ 160,114.50	$ 3.06	$ 160,114.50	$ 320,229.00
Electrical							
Electrical Service/Distribution	52,325	SF	$2.31	$ 120,870.75	$ 2.31	$ 120,870.75	$ 241,741.50
Lighting & Branch Wiring	52,325	SF	$40.00	$ 2,093,000.00	$ 20.94	$ 1,095,685.50	$ 3,188,685.50
Communications & Security	52,325	SF	$2.56	$ 133,952.00	$ 2.56	$ 133,952.00	$ 267,904.00
Specialty Electrical Systems	52,325	SF	$4.84	$ 253,253.00	$ 4.84	$ 253,253.00	$ 506,506.00
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 19,015,372.38
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$4,753,843.09
						ARCHITECT FEES : 9% =	$1,711,383.51
						LOWER LEVEL 3 ESTIMATE TOTAL=	$ 25,480,598.99

Lower Level 1							
			COST PER UNIT		ADDITIONAL COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
Lower Level 1	52,325	SF					
Sheet Vinyl Flooring	20406.75	SF	$ 9.00	$ 183,660.75	$ 20.00	$ 408,135.00	$ 591,795.75
Vinyl Composite Tile	31918.25	SF	$ 10.00	$ 319,182.50	$ 20.00	$ 638,365.00	$ 957,547.50
Shell							
Shell Superstructure							
Floor Construction	52325	SF	$ 12.42	$ 649,876.50	$ 14.90	$ 779,642.50	$ 1,429,519.00
Beams	1,128	CY	$ 260.00	$ 293,207.20	$ 130.00	$ 146,603.60	$ 439,810.80
Roof Construction	17,267	SF	$ 1.78	$ 30,735.71	$ 10.68	$ 184,414.23	$ 215,149.94
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Doors	469	SF	$ 9.26	$ 4,345.72	$ 1,251.00	$ 218,925.00	$ 223,270.72
Ceiling	52325	SF	$ 5.89	$ 308,194.25	$ 3.38	$ 591.50	$ 308,785.75
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 5.89	$ 41,230.00	$ 93,730.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,445.00	$ 32,153.38
Plumbing							
Plumbing Fixtures	101.7759	SF	$ 7.39	$ 752.12	$ 3,074.00	$ 312,859.13	$ 313,611.25
Domestic Water Distribution	52325	SF	$ 12.44	$ 650,923.00	$ 12.44	$ 650,923.00	$ 1,301,846.00
HVAC							
Distribution Equipment	52325	SF	$ 4.25	$ 222,381.25	$ 4.25	$ 222,381.25	$ 444,762.50
Cool Generating Systems	52325	SF	$ 3.10	$ 162,207.50	$ 3.10	$ 162,207.50	$ 324,415.00
Fire Protection							
Sprinklers	52,325	SF	$ 3.06	$ 160,114.50	$ 3.06	$ 160,114.50	$ 320,229.00
Electrical							
Electrical Service/Distribution	52,325	SF	$ 2.31	$ 120,870.75	$ 2.31	$ 120,870.75	$ 241,741.50
Lighting & Branch Wiring	52,325	SF	$ 40.00	$ 2,093,000.00	$ 20.94	$ 1,095,685.50	$ 3,188,685.50
Communications & Security	52,325	SF	$ 2.56	$ 133,952.00	$ 2.56	$ 133,952.00	$ 267,904.00
Specialty Electrical Systems	52,325	SF	$ 4.84	$ 253,253.00	$ 4.84	$ 253,253.00	$ 506,506.00
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 17,121,111.58
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 4,280,277.89
						ARCHITECT FEES : 9% =	$ 1,540,900.04
						LOWER LEVEL 1 ESTIMATE TOTAL=	$ 22,942,289.52

Level 1							
			COST PER UNIT		ADDITIONAL COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
Level 1	52,325	SF					
Flooring							
Sheet Vinyl Flooring	20406.75	SF	$ 9.00	$ 183,660.75			$ 183,660.75
Vinyl Composite Tile	31918.25	SF	$ 10.00	$ 319,182.50			$ 319,182.50
Shell							
Superstructure							
Floor Construction	52325	SF	$ 12.42	$ 649,876.50	$ 14.90	$ 779,642.50	$ 1,429,519.00
Beams	1,128	CY	$ 260.00	$ 293,207.20	$ 130.00	$ 146,603.60	$ 439,810.80
Roof Construction	17,267	SF	$ 1.78	$ 30,735.71	$ 10.68	$ 184,414.23	$ 215,149.94
Exterior Enclosure						$ -	
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Doors	469	SF	$ 9.26	$ 4,345.72	$ 1,251.00	$ 218,925.00	$ 223,270.72
Ceiling	52325	SF	$ 5.89	$ 308,194.25	$ 3.38	$ 591.50	$ 308,785.75
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 5.89	$ 41,230.00	$ 93,730.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,445.00	$ 32,153.38
Plumbing							
Plumbing Fixtures	101.7759	SF	$ 7.39	$ 752.12	$ 3,074.00	$ 312,859.13	$ 313,611.25
Domestic Water Distribution	52325	SF	$ 12.44	$ 650,923.00	$ 12.44	$ 650,923.00	$ 1,301,846.00
HVAC							
Distribution Equipment	52325	SF	$ 4.25	$ 222,381.25	$ 4.25	$ 222,381.25	$ 444,762.50
Cool Generating Systems	52325	SF	$ 3.10	$ 162,207.50	$ 3.10	$ 162,207.50	$ 324,415.00
Fire Protection							
Sprinklers	52,325	SF	$ 3.06	$ 160,114.50	$ 3.06	$ 160,114.50	$ 320,229.00
Electrical							
Electrical Service/Distribution	52,325	SF	$ 2.31	$ 120,870.75	$ 2.31	$ 120,870.75	$ 241,741.50
Lighting & Branch Wiring	52,325	SF	$ 40.00	$ 2,093,000.00	$ 20.94	$ 1,095,685.50	$ 3,188,685.50
Communications & Security	52,325	SF	$ 2.56	$ 133,952.00	$ 2.56	$ 133,952.00	$ 267,904.00
Specialty Electrical Systems	52,325	SF	$ 4.84	$ 253,253.00	$ 4.84	$ 253,253.00	$ 506,506.00
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 16,074,611.58
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 4,018,652.89
						ARCHITECT FEES : 9% =	$ 1,446,715.04
						LEVEL 1 ESTIMATE TOTAL=	$ 21,539,979.52

LEVEL 2: Neonatal Intensive Care Unit (NICU)							
			COST PER SF		ADDITIONAL SUBCONTRACTOR COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
FLOOR 2 Square Feet	37,765	SF					
Shell Superstructure							
Floor Construction	37765	SF	$ 12.42	$ 469,041.30	$ 14.90	$ 562,698.50	$ 1,031,739.80
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 3.38	$ 591.50	$ 53,091.50
Interior Doors	420	SF	$ 9.26	$ 3,885.60	$ 1,251.00	$ 218,925.00	$ 222,810.60
Ceiling	37765	SF	$ 5.89	$ 222,435.85	$ 5.89	$ 222,435.85	$ 444,871.70
Floor Finishes	37765	SF	$ 8.90	$ 336,108.50	$ 8.90	$ 336,108.50	$ 672,217.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,968.64	$ 32,677.02
Plumbing							
Plumbing Fixtures	90.75904	SF	$ 7.39	$ 670.71	$ 3,074.00	$ 278,993.28	$ 279,663.99
Domestic Water Distribution	37765	SF	$ 12.44	$ 469,796.60	$ 12.44	$ 469,796.60	$ 939,593.20
HVAC						$ -	
Distribution Equipment	37765	SF	$ 4.25	$ 160,501.25	$ 4.25	$ 160,501.25	$ 321,002.50
Cool Generating Systems	37765	SF	$ 3.10	$ 117,071.50	$ 3.10	$ 117,071.50	$ 234,143.00
Fire Protection							
Sprinklers	37,765	SF	$ 3.06	$ 115,560.90	$ 3.06	$ 115,560.90	$ 231,121.80
Electrical							
Electrical Service/Distribution	37,765	SF	$ 2.31	$ 87,237.15	$ 2.31	$ 87,237.15	$ 174,474.30
Lighting & Branch Wiring	37,765	SF	$ 40.00	$ 1,510,600.00	$ 20.94	$ 790,799.10	$ 2,301,399.10
Communications & Security	37,765	SF	$ 2.56	$ 96,678.40	$ 2.56	$ 96,678.40	$ 193,356.80
Specialty Electrical Systems	37,765	SF	$ 4.84	$ 182,782.60	$ 4.84	$ 182,782.60	$ 365,565.20
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 13,755,008.03
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 3,438,752.01
						ARCHITECT FEES: 9% =	$ 1,237,950.72
						NICU GRAND ESTIMATE TOTAL=	$ 18,431,710.77

LEVEL 3: Fetal (Half Shell)							
			COST PER SF		ADDITIONAL SUBCONTRACTOR COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
FLOOR 3	37,765	SF					
Shell Superstructure							
Floor Construction	37765	SF	$ 12.42	$ 469,041.30	$ 14.90	$ 562,698.50	$ 1,031,739.80
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Doors	420	SF	$ 9.26	$ 3,885.60	$ 1,251.00	$ 218,925.00	$ 222,810.60
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 3.38	$ 591.50	$ 53,091.50
Ceiling	37765	SF	$ 5.89	$ 222,435.85	$ 5.89	$ 222,435.85	$ 444,871.70
Floor Finishes	37765	SF	$ 8.90	$ 336,108.50	$ 8.90	$ 336,108.50	$ 672,217.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,968.64	$ 32,677.02
Plumbing							
Plumbing Fixtures	90.759	SF	$ 7.39	$ 670.71	$ 3,074.00	$ 278,993.28	$ 279,663.99
Domestic Water Distribution	37765	SF	$ 12.44	$ 469,796.60	$ 12.44	$ 469,796.60	$ 939,593.20
HVAC							
Distribution Equipment	37765	SF	$ 4.25	$ 160,501.25	$ 4.25	$ 160,501.25	$ 321,002.50
Cool Generating Systems	37765	SF	$ 3.10	$ 117,071.50	$ 3.10	$ 117,071.50	$ 234,143.00
Fire Protection							
Sprinklers	37,765	SF	$ 3.06	$ 115,560.90	$ 3.06	$ 115,560.90	$ 231,121.80
Electrical							
Electrical Service/Distribution	37,765	SF	$ 2.31	$ 87,237.15	$ 2.31	$ 87,237.15	$ 174,474.30
Lighting & Branch Wiring	37,765	SF	$ 40.00	$ 1,510,600.00	$ 20.94	$ 790,799.10	$ 2,301,399.10
Communications & Security	37,765	SF	$ 2.56	$ 96,678.40	$ 2.56	$ 96,678.40	$ 193,356.80
Specialty Electrical Systems	37,765	SF	$ 4.84	$ 182,782.60	$ 4.84	$ 182,782.60	$ 365,565.20
						SUBCONTRACTOR ESTIMATE TOTAL =	$ 13,755,008.03
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 3,438,752.01
						ARCHITECT FEES 9% =	$ 1,237,950.72
						FETAL GRAND ESTIMATE TOTAL=	$ 18,431,710.77

LEVEL 4: CARDIAC CARE UNIT (CCU)							
			COST PER SF		ADDITIONAL SUBCONTRACTOR COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
FLOOR 4	37,765	SF					
Shell Superstructure							
Floor Construction	37765	SF	$ 12.42	$ 469,041.30	$ 14.90	$ 562,698.50	$ 1,031,739.80
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure						$ -	
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 3.38	$ 591.50	$ 53,091.50
Interior Doors	420	SF	$ 9.26	$ 3,885.60	$ 1,251.00	$ 218,925.00	$ 222,810.60
Ceiling	37765	SF	$ 5.89	$ 222,435.85	$ 5.89	$ 222,435.85	$ 444,871.70
Floor Finishes	37765	SF	$ 8.90	$ 336,108.50	$ 8.90	$ 336,108.50	$ 672,217.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,968.64	$ 32,677.02
Plumbing							
Plumbing Fixtures	90.75904	SF	$ 7.39	$ 670.71	$ 3,074.00	$ 278,993.28	$ 279,663.99
Domestic Water Distribution	37765	SF	$ 12.44	$ 469,796.60	$ 12.44	$ 469,796.60	$ 939,593.20
HVAC							
Distribution Equipment	37765	SF	$ 4.25	$ 160,501.25	$ 4.25	$ 160,501.25	$ 321,002.50
Cool Generating Systems	37765	SF	$ 3.10	$ 117,071.50	$ 3.10	$ 117,071.50	$ 234,143.00
Fire Protection							
Sprinklers	37,765	SF	$ 3.06	$ 115,560.90	$ 3.06	$ 115,560.90	$ 231,121.80
Electrical							
Electrical Service/Distribution	37,765	SF	$ 2.31	$ 87,237.15	$ 2.31	$ 87,237.15	$ 174,474.30
Lighting & Branch Wiring	37,765	SF	$ 40.00	$ 1,510,600.00	$ 20.94	$ 790,799.10	$ 2,301,399.10
Communications & Security	37,765	SF	$ 2.56	$ 96,678.40	$ 2.56	$ 96,678.40	$ 193,356.80
Specialty Electrical Systems	37,765	SF	$ 4.84	$ 182,782.60	$ 4.84	$ 182,782.60	$ 365,565.20
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 13,755,008.03
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 3,438,752.01
						ARCHITECT FEES 9% =	$ 1,237,950.72
						CCU GRAND ESTIMATE TOTAL =	$ 18,431,710.77

LEVEL 5: PEDIATRIC INTENSIVE CARE UNIT (PICU)							
			COST PER SF		ADDITIONAL SUBCONTRACTOR COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
FLOOR 5	37,765	SF					
Shell Superstructure							
Floor Construction	37765	SF	$ 12.42	$ 469,041.30	$ 14.90	$ 562,698.50	$ 1,031,739.80
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Doors	420	SF	$ 9.26	$ 3,885.60	$ 1,251.00	$ 218,925.00	$ 222,810.60
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 3.38	$ 591.50	$ 53,091.50
Ceiling	37765	SF	$ 5.89	$ 222,435.85	$ 5.89	$ 222,435.85	$ 444,871.70
Floor Finishes	37765	SF	$ 8.90	$ 336,108.50	$ 8.90	$ 336,108.50	$ 672,217.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,906.63	$ 32,615.01
Plumbing							
Plumbing Fixtures	90.75904	SF	$ 7.39	$ 670.71	$ 3,074.00	$ 278,993.28	$ 279,663.99
Domestic Water Distribution	37765	SF	$ 12.44	$ 469,796.60	$ 12.44	$ 469,796.60	$ 939,593.20
HVAC							
Distribution Equipment	37765	SF	$ 4.25	$ 160,501.25	$ 4.25	$ 160,501.25	$ 321,002.50
Cool Generating Systems	37765	SF	$ 3.10	$ 117,071.50	$ 3.10	$ 117,071.50	$ 234,143.00
Fire Protection							
Sprinklers	37,765	SF	$ 3.06	$ 115,560.90	$ 3.06	$ 115,560.90	$ 231,121.80
Electrical							
Electrical Service/Distribution	37,765	SF	$ 2.31	$ 87,237.15	$ 2.31	$ 87,237.15	$ 174,474.30
Lighting & Branch Wiring	37,765	SF	$ 40.00	$ 1,510,600.00	$ 20.94	$ 790,799.10	$ 2,301,399.10
Communications & Security	37,765	SF	$ 2.56	$ 96,678.40	$ 2.56	$ 96,678.40	$ 193,356.80
Specialty Electrical Systems	37,765	SF	$ 4.84	$ 182,782.60	$ 4.84	$ 182,782.60	$ 365,565.20
						SUBCONTRACTOR ESTIMATE TOTAL =	$ 13,754,946.02
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 3,438,736.51
						ARCHITECT FEES 9% =	$ 1,237,945.14
						PICU GRAND ESTIMATE TOTAL=	$ 18,431,627.67

LEVEL 6							
			COST PER SF		ADDITIONAL SUBCONTRACTOR COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
FLOOR 6	37,765	SF					
Shell Superstructure							
Floor Construction	37765	SF	$ 12.42	$ 469,041.30	$ 14.90	$ 562,698.50	$ 1,031,739.80
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Interior							
Interior Doors	420	SF	$ 9.26	$ 3,885.60	$ 1,251.00	$ 218,925.00	$ 222,810.60
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 3.38	$ 591.50	$ 53,091.50
Ceiling	37765	SF	$ 5.89	$ 222,435.85	$ 5.89	$ 222,435.85	$ 444,871.70
Floor Finishes	37765	SF	$ 8.90	$ 336,108.50	$ 8.90	$ 336,108.50	$ 672,217.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,445.00	$ 32,153.38
Plumbing							
Plumbing Fixtures	90.75904	SF	$ 7.39	$ 670.71	$ 3,074.00	$ 278,993.28	$ 279,663.99
omestic Water Distributic	37765	SF	$ 12.44	$ 469,796.60	$ 12.44	$ 469,796.60	$ 939,593.20
HVAC							
Distribution Equipment	37765	SF	$ 4.25	$ 160,501.25	$ 4.25	$ 160,501.25	$ 321,002.50
Cool Generating Systems	37765	SF	$ 3.10	$ 117,071.50	$ 3.10	$ 117,071.50	$ 234,143.00
Fire Protection							
Sprinklers	37,765	SF	$ 3.06	$ 115,560.90	$ 3.06	$ 115,560.90	$ 231,121.80
Electrical							
ctrical Service/Distributi	37,765	SF	$ 2.31	$ 87,237.15	$ 2.31	$ 87,237.15	$ 174,474.30
ighting & Branch Wiring	37,765	SF	$ 40.00	$ 1,510,600.00	$ 20.94	$ 790,799.10	$ 2,301,399.10
ommunications & Securit	37,765	SF	$ 2.56	$ 96,678.40	$ 2.56	$ 96,678.40	$ 193,356.80
pecialty Electrical System	37,765	SF	$ 4.84	$ 182,782.60	$ 4.84	$ 182,782.60	$ 365,565.20
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 13,754,484.39
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 3,438,621.10
						ARCHITECT FEES 9%=	$ 1,237,903.60
						LEVEL 6 ESTIMATE TOTAL=	$ 18,431,009.09

LEVEL 7							
			COST PER SF		ADDITIONAL SUBCONTRACTOR COSTS		
Description	Quantity	Unit	Material	Extension	Labor	Extension	Total
FLOOR 7	37,765	SF					
Shell Superstructure							
Floor Construction	37765	SF	$ 12.42	$ 469,041.30	$ 14.90	$ 562,698.50	$ 1,031,739.80
Beams	866	CY	$ 260.00	$ 225,088.36	$ 130.00	$ 112,544.18	$ 337,632.53
Exterior Enclosure							
Exterior Walls	9600	SF	$ 4.15	$ 39,840.00	$ 19.02	$ 182,592.00	$ 222,432.00
Exterior Windows	9600	SF	$ 2.46	$ 23,616.00	$ 591.00	$ 5,673,600.00	$ 5,697,216.00
Exterior Doors	9600	SF	$ 0.83	$ 7,968.00	$ 5,971.00	$ 5,971.00	$ 13,939.00
Roofing							
Roof Coverings	37765	SF	$ 0.93	$ 35,121.45	$ 5.58	$ 210,728.70	$ 245,850.15
Roof Openings	37765	SF	$ 0.04	$ 1,510.60	$ 0.24	$ 9,063.60	$ 10,574.20
Interior							
Interior Doors	420	SF	$ 9.26	$ 3,885.60	$ 1,251.00	$ 218,925.00	$ 222,810.60
Interior Wall Finishes	7,000	LF	$ 7.50	$ 52,500.00	$ 3.38	$ 591.50	$ 53,091.50
Ceiling	37765	SF	$ 5.89	$ 222,435.85	$ 5.89	$ 222,435.85	$ 444,871.70
Floor Finishes	37765	SF	$ 8.90	$ 336,108.50	$ 8.90	$ 336,108.50	$ 672,217.00
Conveying							
Elevator	1	EA	$ 229,667.00	$ 28,708.38	$ 6.89	$ 3,445.00	$ 32,153.38
Plumbing							
Plumbing Fixtures	90.7590361	SF	$ 7.39	$ 670.71	$ 3,074.00	$ 278,993.28	$ 279,663.99
Domestic Water Distribution	37765	SF	$ 12.44	$ 469,796.60	$ 12.44	$ 469,796.60	$ 939,593.20
HVAC							
Distribution Equipment	37765	SF	$ 4.25	$ 160,501.25	$ 4.25	$ 160,501.25	$ 321,002.50
Cool Generating Systems	37765	SF	$ 3.10	$ 117,071.50	$ 3.10	$ 117,071.50	$ 234,143.00
Fire Protection							
Sprinklers	37,765	SF	$ 3.06	$ 115,560.90	$ 3.06	$ 115,560.90	$ 231,121.80
Electrical							
Electrical Service/Distribution	37,765	SF	$ 2.31	$ 87,237.15	$ 2.31	$ 87,237.15	$ 174,474.30
Lighting & Branch Wiring	37,765	SF	$ 40.00	$ 1,510,600.00	$ 20.94	$ 790,799.10	$ 2,301,399.10
Communications & Security	37,765	SF	$ 2.56	$ 96,678.40	$ 2.56	$ 96,678.40	$ 193,356.80
Specialty Electrical Systems	37,765	SF	$ 4.84	$ 182,782.60	$ 4.84	$ 182,782.60	$ 365,565.20
						SUBCONTRACTOR ESTIMATE TOTAL=	$ 14,024,847.74
						CONTRACTOR FEES: Overhead 5%, Profit 5%, G.Req 15% =	$ 3,506,211.94
						ARCHITECT FEES 9%=	$ 1,262,236.30
						LEVEL 7 ESTIMATE TOTAL=	$ 18,793,295.98

Miscelaneous									
			MATERIAL		LABOR	SUBCONTRACTOR			
Description	Quantity	Unit	Unit Price	Extension	Unit Price	Extension	Unit Price	Extension	Total
Shoring									
Excavation	84000	CF							
Concrete Fill	3111.111	CY	$ 260.00	$ 808,888.89	$ 350.00	$ 1,088,888.89			$ 1,897,777.78
Generators									
Diesel Generator (2000KW)	1	EA							
Diesel Generator (1250KW)	2	EA	$ 51,000	$ 102,000	$ 1,500.00	$ 1,500.00			$ 103,500.00
Electrical									
4000 Amp Main SwitchBoarc	4	EA	$ 31,000	$ 124,000	$ 1,500.00	$ 1,500.00			$ 125,500.00
Heat Generating Systems									
Boilers	2	EA	$ 43,625.00	$ 87,250.00	$ 0.55	$ 220,000.00			$ 307,250.00
								MISCELANEOUS TOTAL=	$ 2,434,027.78

Alternates									
			MATERIAL		LABOR	SUBCONTRACTOR			
Description	Quantity	Unit	Unit Price	Extension	Unit Price	Extension	Unit Price	Extension	Total
ALT #1									
Voided Slabs									
Slab	6798	CY	$ 260.00	$ 1,767,480.00	$ 130.00	$ 883,740.00			$ 2,651,220.00
Beams	5196	CY	$ 260.00	$ 1,350,960.00	$ 130.00	$ 675,480.00			$ 2,026,440.00
ALT #2									
Energy Piles									
Piping	60000	LF	$ 1.30	$ 78,000.00					$ 78,000.00
Excavation	46629	CF							
Concrete Fill	1727	CY	$ 260.00	$ 449,020.00	$ 130.00	$ 224,510.00			$ 673,530.00
ALT #3									
Terrat Wall System	57600	SF	$ 278.75	$ 16,056,000.00	$ 299.75	$ 17,265,600.00			$ 33,321,600.00
ALT #4									
Shelters									
Pressurized Stairway	1	EA	$350,000.00	$ 350,000.00		(Allowance for Pressurized Stairway)			$ 350,000.00
Safe Room Allowance	8	EA	$ 250,000.00	$ 2,000,000.00		(Allowance for Safe Rooms)			$ 2,000,000.00
ALT #5									$ -
Smart Building Control Systems	435890	SF	$ 4.00	$ 1,743,560.00	$ 5	$ 2,179,450.00			$ 3,923,010.00
								ALTERNATES TOTAL =	$ 38,750,790.00

Estimate Summary					
Lower Level 5	Total =	$ 23,700,487.31	Alternate #1: Voided Slab System	Total =	$ 4,677,660.00
Lower Level 3	Total =	$ 25,480,598.99	Alternate #2: Energy Piles	Total =	$ 751,530.00
Lower Level 1	Total =	$ 22,942,289.52	Alternate #3: Terrat Wall System	Total =	$ 33,321,600.00
Level 1	Total =	$ 21,539,979.52	Alternate #4: Shelters	Total =	$ 2,350,000.00
Level 2	Total =	$ 18,431,710.77	Alternate #5: Smart Building Control Systems	Total =	$ 3,923,010.00
Level 3	Total =	$ 18,431,710.77			
Level 4	Total =	$ 18,431,710.77	Omaha Childrens Hospital Grand Total =		$ 207,048,448
Level 5	Total =	$ 18,431,627.67			
Level 6	Total =	$ 18,431,009.09	Grand Total Including Add Alternates =		$ 252,072,248
Level 7	Total =	$ 18,793,295.98			
Miscelaneous	Total =	$ 2,434,027.78	*Note: General Conditions & Fees are included in each floor		

MUREX

EST 2017-18

PROJECT

CHILDREN'S HOSPITAL & MEDICAL CENTER OF OMAHA

TITLE

ESTIMATE SCHEDULE

C-101